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Economic Impact Analysis of Effluent Limitations and Standards for the Electrical and Electronic Components Industry - Phase 1

JRB Associates, Inc., McLean, VA

Prepared for

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This report analyzes the economic impacts of promulgated effluent limitations guidelines for the Electrical and Electronic Components Industry - Phase 1. The Phase I guidelines cover the manufacture of electronic crystals and semiconductors. These regulations were published on April 8 in the Federal Register (48 FR 15382). The report includes a characterization of the industry, and analyzes primary effects of costs to comply with promulgated regulations in terms of price increase, profitability changes and access to capital funds. Secondary effects examined are plant closures, employment changes, regional impacts and foreign trade effects. The report concludes that these regulations will not have a significant impact on the affected industry.

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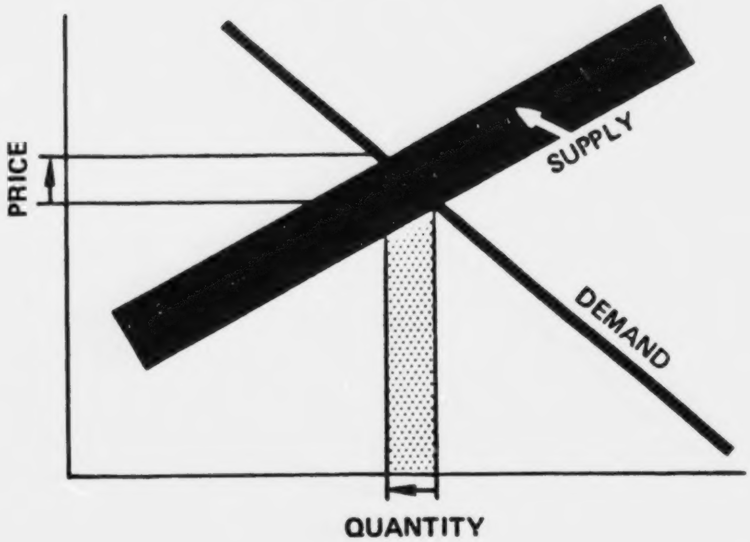

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ECONOMIC IMPACT ANALYSIS OF EFFLUENT LIMITATIONS AND STANDARDS FOR THE ELECTRICAL AND ELECTRONIC COMPONENTS INDUSTRY

PHASE I

Submitted to:

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This document is an economic impact assessment of the recently-issued effluent guidelines. The report is being distributed to EPA Regional Offices and state pollution control agencies and directed to the staff responsible for writing industrial discharge permits. The report includes detailed information on the costs and economic impacts of various treatment technologies. It should be helpful to the permit writer in evaluating the economic impacts on an industrial facility that must comply with effluent limitation guidelines or water quality standards.

The report is also being distributed to EPA Regional Libraries, and copies are available from the National Technical Information Service (NTIS), 5282 Port Royal Road, Springfield, Virginia 22161 (703/487-4600).

If you have any questions about this report, or if you would like additional information on the economic impact of the regulation, please contact the Economic Analysis Staff in the Office of Water Regulations and Standards at EPA Headquarters:

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PREFACE

This document is a contractor's study prepared for the Office of Water Regulations and Standards of the Environmental Protection Agency (EPA). The purpose of the study is to analyze the economic impact which could result from the application of effluent standards and limitations issued under Sections 301, 304, 306, and 307 of the Clean Water Act to the electrical and electronic components industry.

The study supplements the technical study (EPA Development Document) supporting the issuance of these regulations. The Development Document surveys existing and potential waste treatment control methods and technology within particular industrial source categories and supports certain standards and limitations based upon an analysis of the feasibility of these standards in accordance with the requirements of the Clean Water Act. Presented in the Development Document are the investment and operating costs associated with various control and treatment technologies. The attached document supplements this analysis by estimating the broader economic effects which might result from the application of various control methods and technologies. This study investigates the effects in terms of product price increases, effects upon employment and the continued viability of affected plants, effects upon foreign trade, and other competitive effects.

The study has been prepared with the supervision and review of the Office of Water Regulations and Standards of EPA. This report was submitted in accordance with Contract No. 68-01-6348, Work Assignment 14, by JRB Associates and was completed in March 1983.

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SUMMARY

1. INTRODUCTION

1.1 Purpose

This report identifies and analyzes the economic impacts which may result from the promulgation of EPA's effluent regulations on the Electronic Crystals and Semiconductors subcategories of the Electrical and Electronic Components point source category. These regulations include effluent limitations and standards based on Best Practicable Control Technology Currently Available (BPT), Best Available Technology Economically Achievable (BAT), Best Conventional Pollutant Control Technology (BCT), New Source Performance Standards (NSPS), and Pretreatment Standards for New and Existing Sources (PSNS and PSES). These are being promulgated under authority of Section 301, 304, 306, 307, and 501 of the Federal Water Pollution Control Act, as Amended by the Clean Water Act of 1977 (Public Law 92-500). The primary economic impact variables assessed in this study include the potential for the regulations to cause plant closures, price changes, unemployment, changes in industry profitability, structure and competition, shifts in the balance of foreign trade, and impacts on small businesses.

1.2 Industry Coverage

This study is concerned with two subcategories of the Electrical and Electronic Products point source category. These are:

- Electronic crystals; and
- Semiconductors.

The Electronic Crystals subcategory as defined for this study includes establishments that manufacture piezoelectric, semiconductor, and liquid crystals. The major products manufactured are:

- Piezoelectric crystals which include quartz, ceramic, yttrium iron garnet, and lithium niobate crystals;
- Semiconducting crystals which include silicon, gallium, arsenide, gallium phosphide, indium arsenide, indium, antimonide, bismuth telluride, and sapphire; and
- Liquid crystals.

For the purpose of setting effluent standards, the Electronic Crystals subcategory was organized into the two following product groups:

- Plants which fabricate gallium arsenide and/or indium arsenide crystals; and
- Plants which fabricate all other electronic crystals.

The Semiconductor subcategory includes establishments that manufacture semiconductors and related devices (SIC 3674) and electronic components not elsewhere classified (SIC 3679). The growing and fabrication of crystals and the assembly of finished electronic products are not included in this subcategory. The major product areas of the SIC 3674 industry segment include:

- Hybrid Integrated Circuits - thick filament, thin film, and multichip devices
- Bipolar Integrated Circuits
- Metal Oxide Silicon Devices
- Transistors
- Diodes and Rectifiers

- Selenium Rectifiers
- Light Sensitive and Light Emitting Devices (solar cells and light emitting diodes)
- Thyristors.

The major product areas of the SIC 3679 industry segment include:

- Magnetic Bubble Memories
- Liquid Crystal Displays.

2. METHODOLOGY

The approach used to assess the economic impacts that may occur as a result of the costs of each regulatory option is to (1) develop an operational description of the price and output behavior of the industry and (2) assess the likely plant-specific responses to the incurrence of the compliance costs enumerated in the body of this report. Thus, industry conditions before and after compliance with the final regulations are compared. Supplemental analyses are used to assess linkages of the Semiconductor and Electronic Crystals industries' conditions to other effects such as employment, community, and balance of trade impacts. These analyses were performed for four regulatory options considered by EPA. The methodology of the study includes nine tasks that can be grouped into seven major steps. Although each step is described independently, there is considerable interdependence among them. Because each of the two subcategories (electronic crystals and semiconductors) were analyzed separately, specific analytical techniques used in some of the steps differ somewhat between the two subcategories. Specifically, the study proceeded using the following seven steps:

Step 1: Description of Industry Characteristics

The first step in the analysis is to develop a description of basic industry characteristics such as the determinants of demand, market structure, the degree of intra-industry competition, and financial performance. The sources for this information include government reports, trade association data, discussions with various trade associations and industry personnel, and an EPA survey of firms in the industry.

Step 2: Industry Supply-Demand Analysis

The second step in the analysis is a determination of the likely changes in market prices and industry production levels resulting from each regulatory option. The estimates of post-compliance price and output levels are used in the plant-level analysis (steps 4 and 5) to determine post-compliance revenue and profit levels for specific plants in each product group.

The supply-demand analysis for this study assumes that in the short to intermediate time periods, electronic crystal and semiconductor manufacturers would attempt to absorb all of the compliance costs, and therefore, there will be no price increase because of the regulations. This assumption derives from an evaluation of the structure, operations, and trends of the two industries.

The post-compliance market price levels (i.e., zero price increases resulting from the regulation) are used, in a later step, to assess the financial conditions of individual electronic crystals and semiconductor manufacturing facilities.

Step 3: Compliance Cost Estimates

Investment and annual compliance costs for the recommended treatment options were estimated by EPA's Effluent Guidelines Division for treatment systems of various selected sizes. Based on these cost estimates, compliance cost curves were developed and then used to estimate plant specific compliance costs.

Step 4: Plant Level Financial Analysis

Two basic financial characteristics are examined: profitability and capital requirements. Both characteristics are examined through standard financial analysis techniques. That is, profitability is measured by both return on assets (crystals) and return on sales (semiconductors). Capital requirements of the final regulations are evaluated in terms of the amount of the initial capital investment in relation to revenues (crystals) and in relation to average industry levels of annual new plant and equipment expenditures (semiconductors).

For the Semiconductors subcategory, the use of these techniques was hampered by a lack of plant-specific data on a number of input variables, such as value of shipments, plant asset values, and profit margins. However, using a number of industry-wide parameters from various published sources in combination with the limited firm-specific data available, estimates were developed for each of the key parameters.

Step 5: Estimation of Plant Closures

This step involves the assessment of the degree of impacts on individual plants. The decision to close a plant, like most major investment decisions, is ultimately judgemental because it involves a wide variety of considerations, many of which cannot be quantified or even identified. These assessments were made by evaluating the above financial variables in conjunction with non-financial and non-quantifiable factors, such as substitutability of products, plant and firm integration, the existence of specialty markets, and expected market growth rates.

Step 6: Assessment of Other Impacts

Once the assessment of plant closures and price and quantity changes are made, other variables which flow from these are analyzed including employment, industry structure, and imports and exports. These impacts are assessed through the use of industry-wide ratios calculated from the available data sources (e.g., value of shipments per employee).

Step 7: Small Business Analysis

This analysis identifies the economic impacts which are likely to result from the promulgation of the regulations on small businesses in the Electronic Crystals and Semiconductors manufacturing industries. The primary economic variables covered are those analyzed in the general economic impact analysis such as plant financial performance, plant closures, and unemployment and community impacts. Most of the information and analytical techniques in the small business analysis are drawn from the general economic impact analysis. The specific conditions of small firms are evaluated against the background of the general conditions in each product group's market. In addition to the general economic impacts discussed in previous steps, two analytical problems are central to this portion of the analysis: the definition of small businesses in the Electronic Components industry and the considerations of alternative regulatory options that might mitigate potential impacts on small businesses.

Size definitions were sought which would account for firm size in comparison to total industry size and in comparison to unit compliance costs (unit compliance costs increase significantly in reverse proportion to plant size). Since available data on compliance cost and production is on a plant basis, the individual production facility, rather than firm is used as the basis for the analysis. For electronic crystals manufacturing plants three size definitions based on plant revenues were examined to provide EPA with alternative definitions of small plants. These size categories are: plants with revenues under $1 million, $3 million, and $5 million, respectively. For semiconductor manufacturing plants the number of employees was the primary variable used to distinguish size. Plants with fewer than 100 employes are considered small and those with 100 to 250 employees are considered medium-small.

The consideration of alternative regulatory options is considered in terms of the most extreme special consideration -- the exemption of small entities from the regulations. The effects of these exemptions on total compliance costs, the economic impacts, and the effectiveness of the regulations are assessed.

3. INDUSTRY CHARACTERISTICS

3.1 Electronic Crystals

In 1978, U.S. production of piezoelectric crystals was estimated to be around $110 million, while that for semiconducting and liquid crystals was $450 million. Shipments of peizoelectric crystals have been growing at an annual rate of 5 percent since 1973, while shipments of semiconducting and liquid crystals have been growing about 17 percent a year between 1969 and 1979. U.S. production of piezoelectric crystals is projected to continue to grow about 3 percent a year to reach $130 million and $160 million in 1983 and 1990, respectively. Meanwhile, shipments of semiconducting crystals are projected to reach $770 million in 1983 and then average about 13 percent a year for the rest of the decade to reach $1.84 billion in 1990.

EPA identified 70 plants that manufacture electronic crystals in the United States, employing about 10,000 employees. The majority of the plants are concentrated in four states: California, Ohio, Pennsylvania, and Texas. More than half of the plants have less than $3 million in product shipments or less than 200 employees. Most electronic crystal producers are diversified, producing other electronic devices in addition to crystals.

The electronic crystals industry exhibits some characteristics of noncompetitive markets. There is a significant amount of industry concentration, low demand elasticities, and a high degree of capital intensity. However, the existence of the threat of foreign competition appears to be a deterent to noncompetitive pricing behavior. For these reasons, most firms in the industry appear to have both the capability and the incentive for absorbing small and moderate amounts of production cost increases in the short and intermediate term.

3.2 Semiconductors

The value of shipments for all semiconductor devices in the U.S. domestic industry was $9.5 billion in 1982. This represented an increase of 5 percent over the 1981 level of shipments. The growth in this industry segment over this period has been a result of the decreases in the prices of semiconductor products which stimulated demand.

Most of the largest semiconductor companies have several domestic plants (usually in the same region of the country) as well as several foreign plants. The semiconductor industry is comprised of a large number of very small and medium sized plants, which are concentrated in a few states. Approximately a third of these plants were located in California. The 1977 Census of Manufactures reports 545 establishments whose primary activity is the manufacture of semiconductors. Based on an EPA industry survey, it is estimated that 257 semiconductor plants will be affected by the regulation. Of these, 77 plants are direct dischargers and 180 are indirect dischargers.

The principal markets for semiconductor devices include the four major market categories:

- Computer
- Industrial
- Consumer
- Government, including military and space.

These markets, with few exceptions, are outperforming the overall economy. They are expected to continue to grow in the future.

The specific nature of the pricing mechanism in the semiconductor industry is not clear, since the available evidence show some characteristics that are indicative of noncompetitive markets and some that are indicative of competitive markets. Although the market pricing mechanism is not precisely determined, it has been shown that the industry has both the incentive and the capability to not raise prices in response to small and moderate levels of mandated pollution control costs.

4. COMPLIANCE COSTS

Based on the analysis of the potential pollutant parameters and treatment-in-place in the Electronic Components industry, EPA identified six treatment technologies that are most applicable for the reduction of the selected pollutants. These treatment technologies are:

- Option 1: Segregation and collection of spent solvents containing toxic organics for reuse, resale, or contract hauling (referred to as solvent management), plus end-of-pipe treatment for pH control.
- Option 2: Option 1 plus end-of-pipe precipitation/clarification for control of fluoride, arsenic, and suspended solids.
- Option 3: Option 1 plus precipitation/clarification of concentrated fluoride wastes for control of fluoride.
- Option 4: Option 2 plus recycle of treated effluent to further reduce pollutant discharges.
- Option 5: Option 2 plus filtration to further reduce pollutant discharges.
- Option 6: Option 5 plus activated carbon to further reduce toxic organics.

The economic impact analysis does not consider treatment options 4 and 6 because they are not technically feasible nationwide. For this reason, the economic impact analysis concentrated on treatment options 1, 2, 3, and 5 only. Table S-1 presents the estimated investment and annual compliance costs for these treatment options for the Electronic Crystals and Semiconductors subcategories.

Table S-2 summarizes the compliance costs of the selected BPT, BAT, NSPS, PSES, and PSNS limitations. All except the selected PSES regulations for the arsenide crystals and BAT regulations for the Semiconductors subcategory will have relatively small compliance costs. The total investment and annual compliance costs for the final regulations are \$5.7 million and \$4.3 million (1982 dollars), respectively.

5. ECONOMIC IMPACTS

As described previously, the primary economic impact variables assessed are industry financial performance, plant closures, unemployment community effects, changes in imports and exports, and industry structure.

5.1 Electronic Crystals

The estimated economic impacts for the Electronic Crystals subcategory are summarized in Table S-3.

Toxic Organics

The control of toxic organics and pH under option 1 is not expected to cause any incremental compliance costs for non-arsenide crystal direct dischargers under BPT and BAT. These plants already control their discharges to the selected treatment level for regulation.

Non-arsenide crystal indirect dischargers covered under this subcategory are expected to incur monitoring costs to comply with the total toxic organics

TABLE S-1. INDUSTRY COMPLIANCE COSTS OF ALTERNATIVE TREATMENT OPTIONS
(in Thousands of 1979 Dollars)

INDUSTRY SEGMENT	TREATMENT OPTION 1		TREATMENT OPTION 2		TREATMENT OPTION 3		TREATMENT OPTION 5	
	Inv.	Annual	Inv.	Annual	Inv.	Annual	Inv.	Annual
ELECTRONIC CRYSTALS								
Gallium/Indium Arsenide								
Indirect Dischargers	8	16	761	560	N/A	N/A	856	614
Direct Dischargers[a/]	0	0	0	0	N/A	N/A	0	0
Subtotal	8	16	761	560	N/A	N/A	856	614
Non-Arsenide Crystals								
Indirect Dischargers	53	109	4,510	3,182	2,731	2,096	4,970	3,452
Direct Dischargers	0	0	0	0	0	0	0	0
Subtotal	53	109	4,510	3,182	2,731	2,096	4,970	3,452
Total Crystals Subcategory	61	125	5,263	3,742	2,731	2,096	5,826	4,066
SEMICONDUCTORS								
Indirect Dischargers	180	369	65,879	49,368	12,147	8,167	74,662	53,916
Direct Dischargers	77	158	28,078	21,026	3,604	2,452	31,811	22,968
Total Semiconductors Subcategory	257	527	93,947	70,394	15,751	10,619	106,473	76,884

N/A = Not applicable. Treatment option not selected by EPA for this product group.

a/ All Electronic Crystal direct dischargers are already in compliance with the regulations.

TABLE S-2. INDUSTRY COMPLIANCE COSTS OF SELECTED TREATMENT OPTIONS (In Thousands of 1982 Dollars[a])

RECOMMENDED REGULATIONS	SELECTED TREATMENT TECHNOLOGY	COMPLIANCE COSTS INVESTMENT	COMPLIANCE COSTS ANNUAL
ELECTRONIC CRYSTALS SUBCATEGORY			
Gallium/Indium Arsenide Crystals			
BPT	Option 2	0	0
BCT	Option 2	0	0
BAT	Option 2	0	0
NSPS	Option 2	0[b]	0[b]
PSES	Option 2	945	696
PSNS	Option 2	0[b]	0[b]
Non-Arsenide Crystals			
BPT	Option 2	0	0
BCT	Option 2	0	0
BAT	Option 2	0	0
NSPS	Option 2	0[b]	0[b]
PSES	Option 1	66	135
PSNS	Option 1	0[b]	0[b]
SEMICONDUCTORS SUBCATEGORY			
BPT	Option 1	96	196
BCT	Option 1	0	0
BAT	Option 3	4,380[c]	2,850[c]
NSPS	Option 3	0[b]	0[b]
PSES	Option 1	223	458
PSNS	Option 1	0[b]	0[b]
TOTAL		5,710	4,335

[a] Adjusted to 1982 dollars using Engineering News Record Construction Cost indexes.

[b] NSPS/PSNS costs are defined as incremental costs from BAT/PSES. Since the recommended NSPS/PSNS limitations are the same as those proposed for BAT/PSES, NSPS/PSNS costs are zero.

[c] Incremental costs from BPT option.

TABLE S-3. SUMMARY OF ESTIMATED ECONOMIC IMPACTS FOR THE ELECTRONIC CRYSTALS SUBCATEGORY

ECONOMIC IMPACT VARIABLES	OPTION 1	OPTION 2	OPTION 3	OPTION 5	SELECTED OPTION
Gallium/Indium Arsenide Crystals					
Annual Compliance Costs/Revenues (%)					
Indirect Dischargers	0-0.2	0-3.5	N/A	0-3.9	0-3.5
Direct Dischargers	0	0	N/A	0	0
Change in Price (%)	0	0	N/A	0	0
Change in Quantity (%)	0	0	N/A	0	0
Change in Profitability					
Indirect Dischargers	Low	Moderate	N/A	Moderate	Moderate
Direct Dischargers	0	0	N/A	0	0
Capital Requirements					
Indirect Dischargers	Low	Moderate	N/A	Moderate	Moderate
Direct Dischargers	0	0	N/A	0	0
Plant Closures due to Regulations	0	0	N/A	0	0
Employment at Closed Plants	0	0	N/A	0	0
Balance of Trade Changes	None	None	N/A	None	None
Industry Structure Changes	None	None	N/A	None	None
Non-Arsenide Crystals					
Annual Compliance Costs/Revenues (%)					
Indirect Dischargers	0-2.1	0.8-7.6	0.2-3.1	0.8-7.6	0-2.1
Direct Dischargers	0	0	0	0	0
Change in Price (%)	0	0	0	0	0
Change in Quantity (%)	0	0	0	0	0
Change in Profitability					
Indirect Dischargers	Moderate	Signif.	Moderate	Signif.	Moderate
Direct Dischargers	0	0	0	0	0
Capital Requirements					
Indirect Dischargers	Low	Moderate	Moderate	Moderate	Low
Direct Dischargers	0	0	0	0	0
Plant Closures due to Regulations	0	0	0	0	0
Employment at Closed Plants	0	0	0	0	0
Balance of Trade Changes	None	None	None	None	None
Industry Structure Changes	None	None	None	None	None

N/A = Not applicable. Treatment option not selected by EPA for this product group.

limitation under PSES. These costs, totaling $66,000 in capital investment and $135,000 in total annual costs, assume that at least the 50 percent of the plants already in compliance with the toxic organic limitation will choose to certify that they do not dump their solvents into the effluent instead of monitoring. The remaining plants are expected, on average, to monitor quarterly. Since the incremental costs of solvent disposal tend to be offset by resale, EPA did not estimate costs for solvent management.

These monitoring costs are expected to cause moderate reductions in profitability for small non-arsenide crystal plants, but no plant closures are expected as a result of this level of control.

EPA conducted a sensitivity analysis for option 1 costs in addition to the above analysis, consisting of two parts. First, the impact of monthly monitoring was estimated for all facilities (some facilities may monitor as frequently as once per month, although EPA cannot identify precisely which ones). In addition to this analysis, costs and impacts were also determined for facilities which may incur "worst case" solvent disposal costs. These costs are developed for facilities that could fall under the requirements of the Resource Conservation and Recovery Act (RCRA) for disposal. The analysis of these costs shows that while the effects on profitability are higher using these costs, the effects are not expected to significantly increase the impact on these facilities and are not expected to cause any plant closures.

Arsenic

Three arsenide crystal plants are expected to incur investment costs totaling $945,000 and annual costs (including monitoring costs) totaling $696,000, as a result of the control of arsenic under option 2 for PSES. One arsenide crystal plant shows relatively high impacts under this control. However, this plant is owned by a large electronics company and supplies crystals to be used in the production of light emitting diodes (LEDs) at other production facilities of the firm. It is expected that the firm will keep this plant operating to maintain control of the source of supply for its raw material. Consequently, no plant closure is expected.

New Sources

The effluent standards and associated technologies for new sources are identical to those for existing sources. Consequently, the economic impacts for new sources will mirror those of existing sources and the promulgated regulations are not expected to foster competitive advantages or disadvantages between new and existing sources.

5.2 Semiconductors

The estimated economic impacts for the semiconductors subcategory are summarized in Table S-4.

Toxic Organics

The control of toxic organics and pH under option 1 for BPT and PSES is expected to cause industry compliance costs for monitoring of $319,000 in capital investment and $654,000 in annual costs. These costs are based on two assumptions, as with the crystals subcategory. First, at least the 50 percent of the facilities currently in compliance with toxic organic limitation are expected to choose to certify that they do not dump solvents into their effluent instead of monitoring. Second, the remaining plants that do monitor will, on average, do so quarterly. Since the incremental costs of solvent disposal tend to be offset by resale, EPA did not estimate costs for solvent management. Monitoring costs are less than 0.2 percent of annual revenues and are not expected to cause other than minor profitability impacts. No plant closures are expected.

In addition to the above analysis, EPA conducted a sensitivity analysis of option 1 costs consisting of two parts. First, the impact of monthly

TABLE S-4. SUMMARY OF ESTIMATED ECONOMIC IMPACTS FOR THE SEMICONDUCTORS SUBCATEGORY

ECONOMIC IMPACT VARIABLES	OPTION 1	OPTION 2	OPTION 3	OPTION 5	SELECTED OPTION
Annual Compliance Costs/Revenues (%)					
Indirect Dischargers	0-0.2	0.1-11.1	0.01-2.0	0.1-12.2	0-0.2
Direct Dischargers	0-0.2	0.1-11.1	0.01-2.0	0.1-12.2	0.01-2.0
Change in Price (%)	0	0	0	0	0
Change in Quantity (%)	0	0	0	0	0
Change in Profitability					
Indirect Dischargers	Low	Signif.	Low	Signif.	Low
Direct Dischargers	Low	Signif.	Low	Signif.	Low
Capital Requirements					
Indirect Dischargers	Low	Signif.	Low	Signif.	Low
Direct Dischargers	Low	Signif.	Low	Signif.	Low
Plant Closures due to Regulations					
Indirect Dischargers	0	34	0	34	0
Direct Dischargers	0	14	0	14	0
Employment at Closed Plants					
Indirect Dischargers	0	1,666	0	1,666	0
Direct Dischargers	0	686	0	686	0
Balance of Trade Changes	None	None	None	None	None
Industry Structure Changes	None	Signif.	None	Signif.	None

monitoring was estimated for all facilities (some facilities may monitor as frequently as once per month, although EPA cannot identify precisely which ones). In addition to this analysis, costs and impacts were also determined for facilities which may incur "worst case" solvent disposal costs. These costs are developed for facilities that could fall under the requirements of the Resource Conservation and Recovery Act (RCRA) for disposal.

The analysis of these costs shows that while the effects of these costs are somewhat higher, they still represent less than 2.3 percent of annual revenues. These costs are expected to cause some profit reductions, but would not cause any plant closures.

Fluoride

EPA's limits on fluoride under option 3 for BAT will require an estimated 52 of 77 facilities to spend a total of $4.4 million in capital investment and $2.9 million annually (including monitoring costs) to comply with the regulations. These costs are not expected to cause other than small reductions in profitability. No plant closures are expected.

New Sources

The effluent standards and associated technologies for new sources are identical to those for existing sources. Consequently, the economic impacts for new sources will mirror those of existing sources and the promulgated regulations are not expected to foster competitive advantages or disadvantages between new and existing sources.

6. SMALL BUSINESS IMPACTS

The Regulatory Flexibility Act (Public Law 96-354) requires EPA to determine if a significant impact on a substantial number of small entities occurs as a result of the proposed regulations. This analysis may be done in conjunction with or as a part of any other analysis conducted by the Agency. The economic impact analysis contains this analysis which indicates that for the selected options, some reduction in the profitability of small plants occurs in both subcategories. However, these declines in financial performance will not be enough to cause any plant closures or job losses for any segment of the regulated population, large or small.

For the Semiconductor industry the pollution control treatment options 2 and 5 would cause 48 small semiconductor plants, or 19 percent of the semiconductor plants identified, to close, and approximately 2,352 people may become unemployed. Because these options were not selected and because the selected options 1 and 3 do not have a significant impact on small plants, a formal regulatory flexibility analysis is not required.

7. LIMITATIONS TO THE ANALYSIS

7.1 ELECTRONIC CRYSTALS

The major limitations relate to the data used in the analysis. Limited economic data was available on a sample of plants in the industry. However, this data was insufficient to develop a formal discounted cash flow analysis to assess plant closure potential. Instead, comparative analysis of financial ratios such as return on investment was used to estimate plant closure potential. Analyses based on this approach do not consider the timing of cash flows and are based on accounting income rather than cash flows. Nevertheless, return on investment analysis is widely used in the financial analysis community and can be expected to provide consistent results for industry-wide assessments.

A number of assumptions were necessary to implement the analysis and to overcome the data limitations. These are:

- There will be no price increase resulting from the regulations

- Financial performance in the survey year (1978) is fairly typical of what might be expected in the initial year for which compliance is required

- Baseline data was based on sample sizes which varied in industry representation from one variable to another

- The yield on U.S. treasury bonds is a threshold value for plant closures.

To assess the potential effects of violations of these assumptions or of errors introduced because of the aforementioned methodology limitations, a sensitivity analysis of plus and minus 20 percent is performed on a number of key variables, such as compliance costs and baseline profit rates. It is concluded that there would be no plant closures under these conditions. Despite the above limitations, the economic impact analysis conclusions appear to be valid within a rather liberal range of potential error.

In addition, a sensitivity analysis is performed (reported in Appendix I-A) to examine the sensitivity of the economic impacts to variations in compliance costs resulting from the control of toxic organics in the effluent. The analysis showed that although varying assumptions on costs (i.e., monthly monitoring versus quarterly monitoring, and worst case solvent disposal costs) did increase the potential for profitability reductions, the general conclusions of the analysis still hold.

7.2 SEMICONDUCTORS

As noted above for the electronic crystals industry, the major limitations relate to the data used in the study. A survey to collect plant-specific financial and economic data was not conducted, and these types of data are not in the public domain for this industry. Instead, most of the plant-specific data used are estimates derived from industry average operating and financial ratios. The plant-specific data must, therefore, be considered order-of-magnitude estimates, and not actual data for specific semiconductor plants. As a result of the lack of adequate data the methodology to assess plant closure is limited to comparisons of simple operating ratios. A more appropriate closure analysis would be based on more formal investment analysis techniques, which rely on precise data on the long-term capital structure, cash flow, and the profitability of plants in the semiconductor industry.

A sensitivity analysis was performed to examine the sensitivity of the conclusions to some of the parameters estimated for the plant closure analysis. The primary variables considered were compliance cost estimates, baseline profit rates (as measured by before tax return on sales) and plant closure threshold criteria. A 20 percent variation in any of these variables would not significantly change the results for the selected option. However, the number of plant closures due to the regulation under options 2 and 5 would increase by 50 percent, to 72 plants.

In addition, a sensitivity analysis is performed (reported in Appendix II-A) to examine the sensitivity of the economic impacts to variations in compliance costs resulting from the control of toxic organics in the effluent. The analysis showed that while varying assumptions on costs (i.e., monthly monitoring costs versus quarterly, and worst case solvent disposal costs) did increase the potential for profitability reductions, the general conclusions of the analysis still hold.

For these reasons, it is concluded that although the above assumptions and limitations may bias the analysis somewhat, the potential changes to the conclusions resulting from elimination of these biases are small.

PART I

ELECTRONIC CRYSTALS SUBCATEGORY

1. INTRODUCTION

1.1 PURPOSE

The purpose of this report is to identify and analyze the economic impacts that are likely to result from the promulgation of regulations for Best Practicable Control Technology (BPT), Best Conventional Pollutant Control Technology (BCT), Best Available Technology Economically Achievable (BAT), New Source Performance Standards (NSPS), and Pretreatment Standards for New and Existing Sources (PSNS and PSES) on the Electronic Crystals subcategory of the Electrical and Electronic Components Point Source Category. The study focuses primarily on the impacts of the proposed EPA regulations on industry profitability, ability to raise investment capital, employment, plant closures, imports and exports, and substitution. In addition, impacts on small business entities are also analyzed.

1.2 SCOPE

The Electronic Crystals subcategory as defined in this study includes establishments that grow and fabricate piezoelectric, semiconducting, and liquid crystals.

Piezoelectric crystals are crystals that have the ability to generate a voltage when a mechanical force is applied, or produce a mechanical force when a voltage is applied. The major types of piezoelectric crystals are quartz, ceramics, and yttrium-iron-garnet (YIG).

Semiconducting crystals are crystals whose electrical resistivity 1/ is intermediate between that of metals (conductors) and insulators (nonconductors). The major types of semiconducting crystals are silicon, gallium arsenide, gallium phosphide, indium arsenide, indium antimonide, bismuth telluride, sapphire, and gallium gadolinium garnet (GGG).

1/ Resistivity is a property of an electrically conducting material which expresses the relative ease (low resistivity) or difficulty (high resistivity) of passage of an electric current.

Liquid crystals are organic compounds that exhibit properties of fluidity and molecular order simultaneously over a small temperature range. An electric field can disrupt the orderly arrangement of liquid crystal molecules and darken the liquid enough to form visible characters in a display assembly.

1.3 TECHNICAL AND ECONOMIC SUBCATEGORIZATION

For the purpose of setting effluent standards, EPA proposed the following two product groups for the Electronic Crystals subcategory:

- Plants that fabricate gallium arsenide and/or indium arsenide crystals; and
- Plants that fabricate all other electronic crystals ("non-arsenide" plants).

EPA identified only eight plants in operation in the U.S. which produce gallium arsenide and indium arsenide crystals. Analyses were performed on each of these plants to assess the potential impacts of the proposed regulations. EPA estimated that 62 plants produce non-arsenide crystals. The assessment of the economic impacts of the proposed regulations for these plants was based on model plants which were developed to represent the 62-plant population. The representative model plants were developed from EPA survey data and were based on plant sizes and wastewater flow rates.

1.4 ORGANIZATION OF PART I OF THIS REPORT

The remainder of Part I of this report is organized into seven sections. Section 2 outlines the study methodologies and Section 3 presents a description of the industry. Section 4 projects the baseline conditions of the industry assuming no further water pollution control requirements. Section 5 details the costs of the alternative treatment technologies being considered. Section 6 presents the economic impacts of pollution control costs. Section 7 addresses the impacts of the regulations on small businesses. Finally, Section 8 discusses the assumptions and limitations of this study.

2. STUDY METHODOLOGY

2.1 OVERVIEW

Figure 2-1 shows an overview of the analytical approach used to assess the economic impacts likely to occur as a result of the costs of each proposed regulatory option. The approach used in this study is to (1) develop an operational description of the price and output behavior of the industry, and (2) assess the likely plant-specific responses to the incurrence of the compliance costs enumerated in Chapter 5.

The operational description of the price and output behavior is used, in conjunction with EPA compliance cost estimates supplied, to determine new post-compliance industry price and production levels for each regulatory option and for each of the two electronic crystal product groups. Individual plant data is then analyzed under conditions of the post-compliance industry price levels, for each regulatory option, to isolate those plants whose production costs would appear to change significantly more than the estimated change in their revenues. These identified plants are subjected to a financial analysis that uses capital budgeting techniques to determine likely plant closures. The industry description is then revised, for each regulatory option, to incorporate the reduced supply into the analysis. Finally, other effects which flow from the basic price, production, and industry structure changes are determined. These include employment, community, and foreign trade impacts. Specifically, the study proceeded in the following nine steps:

1. Description of industry characteristics;
2. Industry supply and demand analysis;
3. Analysis of cost of compliance estimates;
4. Plant level screening analysis;
5. Plant level profitability analysis;
6. Plant level capital requirements analysis;
7. Assessment of plant closure potential;
8. Assessment of other impacts; and
9. Small business analysis.

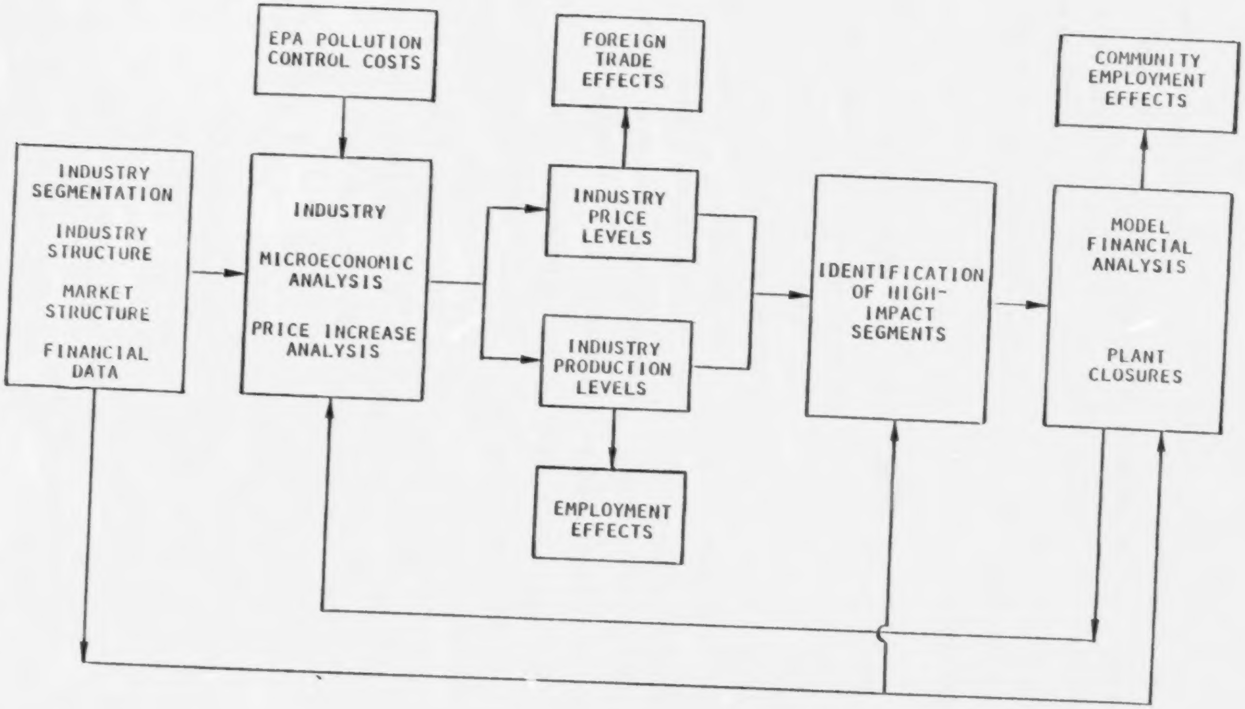
INDUSTRY SEGMENTATION
INDUSTRY STRUCTURE
MARKET STRUCTURE
FINANCIAL DATA
EPA POLLUTION CONTROL COSTS
INDUSTRY
MICROECONOMIC ANALYSIS
PRICE INCREASE ANALYSIS
FOREIGN TRADE EFFECTS
INDUSTRY PRICE LEVELS
INDUSTRY PRODUCTION LEVELS
EMPLOYMENT EFFECTS
IDENTIFICATION OF HIGH-IMPACT SEGMENTS
COMMUNITY EMPLOYMENT EFFECTS
MODEL FINANCIAL ANALYSIS
PLANT CLOSURES

FIGURE 2-1. ECONOMIC ANALYSIS STUDY OVERVIEW

Although each of these steps is described separately in this section, it is important to realize that there are significant interactions between them, as shown in Figure 2-1.

2.2 STEP 1: DESCRIPTION OF INDUSTRY CHARACTERISTICS

The first step in the analysis is to describe the basic industry characteristics. These characteristics, which include the determinants of demand, market structure, the degree of intra-industry competition, and financial performance, are described in Chapter 3 of this report.

The sources for this information include government reports, trade association data, discussions with various trade association representatives and individuals associated with the industry, and an EPA industry survey under Section 308 of the Clean Water Act.

2.3 STEP 2: SUPPLY-DEMAND ANALYSIS

The purpose of the supply-demand analysis is to determine the likely changes in market prices and industry production levels resulting from each regulatory option. The estimates of post-compliance price and output levels are used in the plant-level analysis to determine post-compliance revenue and profit levels for specific plants in each product group. If prices are successfully raised without significantly reducing product demand and companies are able to maintain their current financial status, the potential for plant closings will be minimal. If prices cannot be raised to fully recover compliance costs because of the potential for a significant decline in product demand or because of significant intra-industry competition, the firms may attempt to maintain their financial status by closing higher cost/less efficient plants. The supply-demand analysis was divided into four basic components: description of industry structure, determination of industry pricing mechanism, projection of possible changes in industry structure during the 1980s (when the primary economic impacts of the regulations will be felt), and determination of plant- and firm-specific operational parameters (e.g., production costs, profit rates, etc.).

Short-run pricing behavior depends upon the market structure of the industry, which can range from competitive to oligopoly, and to monopoly situations. Many economic impact studies begin by assuming perfect competition. However, the product groups covered in this study exhibit some characteristics that are indicative of non-competitive pricing mechanisms.

The perfectly competitive market structure is one in which there are many buyers and sellers and the actions of any one of these do not significantly affect the market. Firms in a competitive market generally earn a "normal" rate of return on their assets. If it is assumed that (1) the market for a competitive good is currently at equilibrium, or will be when the regulations become effective, and (2) firms will attempt to maintain their current financial status by passing through industry-wide cost increases in the form of higher prices, the post-compliance equilibrium price and quantity level can be derived from the interaction of the elasticities of supply and demand. That is, the amount of the cost increase that will be passed through into higher prices is

$$\frac{E_s}{E_d + E_s} \qquad (1)$$

where E_s is the elasticity of supply and E_d is the elasticity of demand.[1/]

The high concentration ratios for some of the product groups and the existence of speciality markets could cause non-competitive pricing behavior. For example, if foreign competition were not a problem, full cost pricing might be assumed to characterize the behavior of oligopolistic firms. The price could be assumed to cover average total cost (the sum of variable cost, average fixed cost, and return on investment) of the "price leaders" in the industry. Thus, one or a few firms may have the ability, because of their

---

[1/] In a competitive market, price = marginal cost, therefore

$E_s = \frac{dQs}{dP} \cdot \frac{P}{Qs} = \frac{dQ_s}{dmc} \cdot \frac{mc}{Qs}$, where mc = marginal cost, P = market price, and Qs = quantity supplied.

See Levenson, Albert M., and Solon, B.S., Outline of Price Theory, Holt, Rinehart and Winston, Inc., pp 56-59, 1964.

market power, to impose their most desired price and output strategy on the other firms in the market.

Oligopolistic pricing schemes are applicable for those product categories which exhibit characteristics of oligopoly markets, such as the following:

- Few firms in the product group;
- High industry concentration;
- Low degree of foreign competition;
- Abnormally high profitability;
- Low demand elasticities;
- Highly capital intensive;
- Large degree of integration of production, marketing, and distribution; and
- Large degree of specialized knowledge.

Industries which exhibit the first three of these characteristics are those in which the pricing and output actions of one firm will directly affect those of other firms in the industry. While these conditions do not guarantee oligopolistic behavior, they are necessary conditions and good indicators that oligopolistic behavior exists. Abnormally high profits in an industry would, in time, normally attract new entrants to the industry, thereby increasing price competition. However, very high profits over long periods of time which are not explained by such factors as excess risk, unusual amounts of technological innovation, or firm size may be an indicator that an imperfect market structure exists. Such conditions may occur when entry into an industry is difficult. The last three of the above points are indicators of difficulty of entry into the market.

Although the domestic electronic crystals industry exhibits some of these characteristics of non-competitive markets, the existence of the threat of foreign competition changes their pricing behavior. That is, if the differential between foreign and domestic prices is in equilibrium, an increase in the domestic price would result in lost market share. Since the domestic producer profits are above "normal" profit rates, they have the capability of absorbing the cost increases without increasing product prices and would probably do so.

Having described the current industry structure, it was necessary to determine if the key parameters would change significantly during the 1980s. Projections of industry conditions begin with a demand forecast. The demand in 1990 is estimated via trend analysis and market research analysis. An examination was also made of the factors which might affect the real cost of manufacturing electronic crystals. No reason was found to expect the real price of these products to increase between now and 1990. It was concluded from the projections of industry conditions that only minor changes in market structure would occur in the base case. For this reason it was concluded that the market structure previously described can be used to determine price changes due to the regulation.

The post-compliance market price levels (i.e., zero price increases due to the regulation) are used, in a later step, to assess the financial condition of individual electronic crystals manufacturing facilities.

2.4 STEP 3: COST OF COMPLIANCE ESTIMATES

Investment and annual compliance costs for the recommended treatment options 1, 2, 3, and 5 were estimated by EPA's Effluent Guidelines Division for treatment systems of various selected sizes. Based on these cost estimates, compliance cost curves were developed and then used to estimate plant-specific compliance costs. A description of the control and treatment technologies and the rationale behind these compliance cost estimates appear in chapter 5.

2.5 STEP 4: PLANT-LEVEL SCREENING ANALYSIS

The screening analysis uses a basic criterion to separate those plants with obviously small impacts from those with potentially significant impacts. The criterion uses the ratio of total annual compliance cost to revenue for each plant; if this ratio is less than one percent, the plant is considered a "low impact" plant. For such plants, the impacts on plant profitabilities are very small. Although some of these plants will probably experience some drop in their profitabilities, they would not be considered candidates for closure. Estimates of profitability changes for these plants were recorded, but they are not subject to a detailed financial analysis. Plants with compliance costs to revenue ratios greater than 1 percent were subjected to a more detailed financial analysis to determine if they are likely plant closures.

2.6 STEP 5: PLANT-LEVEL PROFITABILITY ANALYSIS

The basic measure of financial performance used to assess the impact of the proposed regulations on the profitabilities of individual plants is return on investment (ROI). The use of this technique involved a comparison of the return on investment after compliance with a minimum required ROI.

The return on investment is defined as the ratio of annual profits before taxes to the gross book value of fixed assets of a plant. It is based on accounting income rather than cash flows and it fails to account for the timing of cash flows, thereby ignoring the time value of money. However, this technique has the virtues of simplicity and common usage in comparative analyses of the profitability of financial entities.

The profit impact assessment is determined by calculating the after-compliance ROI for each plant and comparing them to the average yield of U.S. Treasury bonds. As discussed in Section 2.3, it is expected that the electronic crystals producers will absorb the costs of compliance and prices will not be raised. As the result, the after-compliance ROI can be estimated as follows:

$$ROI_{2i} = \frac{PROFIT_{1i} - ACC_i}{A_i + CCI_i} \quad (2)$$

$$PROFIT_{1i} = R_{1i} \times PM_{1i} \quad (3)$$

where ROI_{2i} = After-compliance ROI of plant i

$PROFIT_{1i}$ = Pre-compliance profit of plant i

ACC_i = Annual compliance cost for plant i

A_i = Pre-compliance capital investment for plant i

CCI_i = Compliance capital investment for plant i
R_{1i} = Pre-compliance revenue of plant i
PM_{1i} = Pre-compliance profit margin of plant i

Plants with after-compliance ROI below 11.5 percent, the average yield of U.S. Treasury bonds for 1980, are considered potential plant closures. The underlying assumption is that plants cannot continue to operate as viable concerns if they are unable to generate a return on investment that is at least equal to the opportunity cost of other lower risk investment alternatives, which in this case is defined as the average yield of the U.S. Treasury bonds.

Most of the data used in this analysis were estimated from a combination of publicly available information and the EPA 308 Survey. The following are the most important variables:

- Baseline financial profiles (i.e., revenues, assets value, profit margin) of individual plants/model plants are obtained from the EPA 308 Survey; and
- Pollution control costs are estimated as described in Step 3.

2.7 STEP 6: CAPITAL REQUIREMENTS ANALYSIS

This section analyzes the ability of firms to make the initial capital investment needed to construct and install the required treatment systems. Some plants which are not initially identified as potential closures in the profitability analysis may encounter problems raising the amount of capital required to install the necessary treatment equipment. The limit on a given firm's ability to raise capital to finance investment expenditures is quite variable, depending upon factors such as the firm's capital structure, profitability, future business prospects, the industry's business climate, the characteristics of the financial markets and the aggregate economy, and the firm management's relationships with the financial community. The precise limit, considering all these factors, is ultimately judgmental. Even with firm-specific data, a limit on a firm's ability (or willingness) to raise funds for capital investment would be difficult to estimate. Because firm-specific data for this study is scarce, the analysis of capital availability was based on the following ratio which provides a good indication of the relative magnitude of the capital requirements for pollution control:

$$\frac{CCI}{R}$$

where

R = plant revenues
CCI = capital compliance investment

Plants with after-compliance ratios greater than the difference between the highest and lowest ratios of annual capital expenditures to value of shipments (CE/VS) between 1970 and 1977 for SIC 3679 (Electronic Components, n.e.c.) as reported by the Census of Manufactures are considered to be potential plant closures. The difference between the highest and lowest CE/VS ratios is considered to be an indicator of the maximum amount of capital available for pollution control investment. That is, the highest CE/VS ratio of 5.1 percent represents the maximum capital expenditure rate that has historically been made available for capital investment. It is assumed that CE/VS ratios below this amount can be successfully attained again by the firms in the industry, since it has been achieved before. The lowest CE/VS ratio of 2.8 percent represents the minimum amount necessary to maintain a targeted rate of industry growth. If the ratio CCI/R for a given plant is greater than the difference between the industry's highest and lowest CE/VS ratios, 2.3 percent, then the plant could experience some difficulties in making the capital investment for pollution control. Although this analytical technique does not precisely indicate whether or not a given firm will be able to raise the necessary funds, it does provide an indication of the relative magnitude of the compliance investment.

Plants with CCI/R ratios greater than the difference between the highest and lowest CE/VS ratios were then subjected to the following cash flow test. Cash flow is defined as net after tax profits plus depreciation charges.

Depreciation is assumed to be 10 percent of fixed assets and the tax rate is assumed to be 40 percent. If the CCI/R ratio is less than the cash flow, th investment may be financed out of a single year's cash flow without addition long-term debt burden.

Although the above analyses provide a good indication of the relative burden created by the compliance requirement, they do not precisely indicate whether or not firms can afford to make the investments. If, for example, t same investment requirements were placed on a firm which is already highly leveraged (as indicated by a high debt/equity ratio) and a firm which is not leveraged (as indicated by a debt/equity ratio of zero), the highly leverage firm is likely to experience the most significant impact. In addition, the capital requirements must be evaluated together with other factors, such as profitability. For example, a plant that is extremely profitable would consider the risk of more leverage or increased cost of capital resulting fr investment more worthwhile than would a less profitable plant.

2.8 STEP 7: PLANT CLOSURE ANALYSIS

The plant-level analysis examined the individual production units in ea product group to determine the potential for plant closures and profitabilit changes. The decision to close a plant, like most major investment decision is ultimately judgmental. This is because the decision involves a wide variety of considerations, many of which cannot be quantified or even identified. Some of the most important factors are:

- Profitability before and after compliance;
- Ability to raise capital;
- Market and technological integration;
- Market growth rate;
- Other pending Federal, state, and local regulations;
- Ease of entry into market;
- Market share;
- Foreign competition;
- Substitutability of the product; and

- Existence of specialty markets.

Many of these factors are highly uncertain, even for the owners of the plants. However, this analysis was structured to make quantitative estimates of the first two factors, as described above, and to qualitatively consider the importance of the others. In this analysis, the first two factors are given the greatest amount of weight, while the importance of the other factors varies from plant to plant.

2.9 STEP 8: OTHER IMPACTS

This analysis addresses economic impacts which flow from the basic price, production, and plant level profitability changes. These impacts include impacts on employment, communities, industry structure, and balance of trade.

The estimate of employment effects flows directly from the outputs of the industry level analysis and the plant closure analysis. Employment estimates for the production facilities projected to close are available from the EPA 308 Survey. Meanwhile, employment in the remaining plants is not expected to decrease because there will be no price increase as the result of the regulations.[2/]

Community impacts result primarily from employment impacts. The critical variable is the ratio of Electronic Crystals industry unemployment to total employment in the community. Data on community employment are available through the Bureau of the Census and the Bureau of Labor Statistics. Sometimes county-wide data will have to be relied upon in the absence of community-specific data, although this was not necessary in this study.

[2/] Some increase in employment might occur at the remaining facilities as substitutes for the eliminated capacity from the closed plants. Quantitative evaluation of this effect was not developed in this study.

The assessment of industry structure changes is based on examination of the following before and after compliance with the regulation:

- Numbers of firms and plants;
- Industry concentration ratios; and
- Effects of plant closures on specialty markets.

Imports and exports are important determinants of pricing behavior in the Electronic Crystals industry. The role of these variables is qualitatively evaluated in Chapter 3 of this report. Basically, the threat of imports appears to deter domestic producers from excessive non-competitive pricing behavior.

2.10 STEP 9: SMALL BUSINESS ANALYSIS

The Regulatory Flexibility Act (RFA) of 1980, (P.L. 96-354) requires Federal regulatory agencies to consider "small entities" throughout the regulatory process. The RFA requires an initial screening analysis to be performed to determine if a substantial number of small entities will be significantly impacted. If so, regulatory alternatives that eliminate or mitigate the impacts must be considered. This step in the study addresses these objectives by identifying the economic impacts which are likely to result from the promulgation of BPT, BCT, BATEA, NSPS, PSES, and PSNS regulations on small businesses in the electronic crystals manufacturing industry. The primary economic variables covered are those analyzed in the general economic impact analysis such as plant financial performance, plant closures, and unemployment and community impacts. Most of the information and analytical techniques in the small business analysis are drawn from the general economic impact analysis which is described above and in the remainder of this report. The specific conditions of small firms are evaluated against the background of general condition in the electronic crystal markets.

A specific problem in the methodology was developing an acceptable definition of small entities. The Small Business Administration (SBA) defines small entities in SIC 3674 (Semiconductors and Related Devices and SIC 3679

(Electronic Components, n.e.c.) as firms of fewer than 500 employees. The SBA definition was found to be inappropriate as a basis for defining small entities in the electronic crystal manufacturing industry for purposes of developing water pollution regulations. Instead, a definition was sought which would account for firm size in comparison to total industry size and in comparison to unit compliance costs (unit compliance costs increase significantly in reverse proportion to plant size). Moreover, since the available data on compliance cost and production was on an individual plant basis, the individual production facility rather than the firm was used as the basis for the analysis.

In the absence of an appropriate specific definition for a small business in the electronic crystals manufacturing industry, three size definitions for electronic crystal manufacturing plants based on plant revenues were selected for examination. Plant revenues were selected to distinguish plant size because plant level employment data were considered less reliable and plant production volume data did not allow consistent comparisons across the product groups. The three size categories are plants with revenues less than $1 million, $3 million and $5 million, respectively. The use of several different size definitions provides EPA with alternatives in defining small electronic crystal operations.

The impacts on small plants under each definition were assessed by examining the distribution by plant size of the number of electronic crystal plants, plant revenues, wastewater volumes, compliance costs and potential closures from the regulations.

3. INDUSTRY DESCRIPTION

This section describes the manufacturing processes and the plant and firm characteristics of the electronic crystals industry. In addition, the characteristics and end uses of crystals and the extent of foreign competition are also examined.

3.1 MANUFACTURING PROCESSES

As indicated earlier, the scope of this study includes the plants that grow and fabricate piezoelectric, semiconducting and liquid crystals. The manufacturing processes for these electronic crystals are generally very similar. First, single crystals are grown from polycrystalline raw materials. The most common technique for growing single crystals is the Czochralski method in which the raw material is melted; a single crystal bar (seed) is then dipped into the melt and raised slowly with rotation to allow the molten material to freeze onto the seed to form a single crystal rod. Other methods based on some variations of the Czochralski method are also used for growing electronic crystals and are described in the Final Development Document.[1/]

After the single crystal rod has been grown, it must be fabricated into a suitable form, which for most applications is a wafer. Generally, the crystal rod is ground to a preferred shape. It is then sliced into thin pieces using diamond blade saws or slurry saws. Once sliced, the crystal wafers are then lapped to obtain a desired thickness and a smoother finish. Finally, the slices are polished to a mirror finish, and are then ready for further processing to produce various electronic components.

3.2 FIRM AND PLANT CHARACTERISTICS

According to EPA estimates, there are approximately 70 producers of electronic crystals in the United States[2/], with total employment of the industry

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[1/] EPA, Final Development Document for Effluent Limitation Guidelines for the Electrical and Electronic Components Point Source Category, March, 1983.

2/Ibid.

estimated at around 10,000 employees. Table 3-1 lists the number of plants by type of crystals. As indicated in the table, with the exception of quartz crystal the production of electronic crystals is highly concentrated with a small number of firms accounting for most of the production of each type of crystal.

The geographical distribution of the plants is shown in Table 3-2. Four states account for 57 percent of the number of plants identified (California, Ohio, Pennsylvania, and Texas, with 26, 12, 12, and 7 percent of the number of plants, respectively), with the remainder widely dispersed throughout the country.

Based on the survey data obtained on 52 plants, about 60 percent of the plants have less than $3 million in product shipments or employ less than 100 employees. Table 3-3 presents a distribution of the electronic crystals plants by plant size. Most of the plants appear to be highly specialized in the fabrication of electronic crystals. Only 12 plants report integration to the manufacture of electronic devices at the same production facilities. The companies that own the crystal plants, on the other hand, are generally more diversified and often produce other electronic devices in addition to crystals, usually at other production facilities.

3.3 PRODUCT CHARACTERISTICS AND USES

As indicated in Section 1, the Electronic Crystals subcategory as defined in this study includes three types of crystals:

- Piezoelectric crystals which include quartz, ceramic, yttrium-iron-garnet, and lithium niobate crystals;
- Semiconducting crystals, which include silicon, gallium arsenide, gallium phosphide, indium arsenide, indium antimonide, bismuth telluride, and sapphire; and
- Liquid crystals.

TABLE 3-1. NUMBER OF ELECTRONIC CRYSTAL PLANTS IN THE UNITED STATES

TYPES OF CRYSTALS	ESTIMATED TOTAL NUMBER OF PLANTS	NUMBER OF PLANTS WITH RETURNED QUESTIONNAIRES
Piezoelectric Crystals		
Quartz	40	27
Ceramics	8	8
Yttrium Iron Garnet (YIG)	3	3
YAG	2	2
Lithium Niobate	3	3
Semiconducting Crystals		
Silicon	8	8
Gallium Arsenide/Phosphide	6	6
Indium Arsenide/ Indium Antimonide/ Bismuth Telluride	1	1
Gallium Gadolinium Garnet (GGG)	3	3
Sapphire	1	1
Liquid Crystal	2	2
TOTAL	70 [a/b/]	57 [a/]

[a/] Columns do not add up because some plants make more than one type of product.

[b/] Projected by JRB assuming that non-respondent plants are single product plants.

Source - EPA, Final Development Document, March 1983

TABLE 3-2. GEOGRAPHICAL DISTRIBUTION OF ELECTRONIC CRYSTAL PLANTS

STATE	NUMBER OF PLANTS
Arizona	1
California	15
Colorado	1
Connecticut	2
Florida	1
Illinois	1
Kansas	1
Massachusetts	1
Missouri	1
Montana	1
New Jersey	3
New York	2
North Carolina	1
Ohio	7
Oklahoma	2
Oregon	1
Pennsylvania	7
South Dakota	1
Texas	4
Utah	2
Not Reported	2
TOTAL	57

Source: EPA 308 Survey

TABLE 3-3. DISTRIBUTION OF PLANTS BY PLANT SIZE

Plant Size[a]	Number of Sample Plants[b]	Percent of Total	Estimated Number of Plants for Total Industry
Gallium Arsenide/Indium Arsenide Crystals			
Extra Small	2	25	2
Small	3	38	3
Medium	-	-	-
Large	3	38	3
	8	100	8
Other Electronic Crystals			
Extra Small	10	23	14
Small	16	36	23
Medium	10	23	14
Large	8	18	11
	44	100	62

[a] Extra Small Plant = Plants with less than $1 million in value of shipments or with less than 20 employees.

Small Plant = Plant with $1 million to $3 million in value of shipments or with 20 to 100 employees.

Medium Plant = Plant with $3 million to $5 million in value of shipments or with 100 to 250 employees.

Large Plant = Plant with over $5 million in value of shipments or with more than 250 employees.

[b] Data on plant size are available only for 52 of 57 plants with survey responses.

Source: EPA Survey

Quartz and silicon crystals are by far the most widely used crystals. The principal end-uses of various electronic crystals are summarized in Table 3-4.

The potential for substitution of electronic crystals in their current applications is limited. For instance, silicon's exceptional physical and chemical properties make this crystal the best and most important material for semiconductor applications. Similarly, the special characteristics of the other crystals make them hard to be replaced in most of their applications.

Potential substitution among various crystals is also limited. Except for gallium arsenide, gallium phosphide, and liquid crystals, which are all used in the manufacturing of display devices, each electronic crystal has quite distinctive applications for which it cannot be easily replaced (see Table 3-4). Gallium arsenide and gallium phosphide can substitute for each other in the fabrication of light emitting diodes (LEDs)--gallium arsenide for red displays and gallium phosphide for green displays--however, each manufacturer can easily produce either or both materials. Therefore, this substitution does not present any problem to the industry. Meanwhile, LEDs and liquid crystal displays (LCDs) compete against each other; however, the potential for substitution is limited due to the special characteristics of each product. Because it requires minimum use of power, LCD has replaced LED in many battery-operated devices such as electronic watches and calculators; however, LCD is not as visible as LED, and thus its substitution for LED is limited.

3.4 TRENDS

Data are not available on U.S. total production of fabricated (i.e., sliced, polished, lapped) electronic crystals. However, the U.S. Department of Commerce reported that shipments of quartz and other crystal filters and frequency control devices (which account for most of the demand for piezoelectric crystals) totaled $148.6 million in 1978. It was estimated that the value of the crystal accounted for about 75 percent of the value of the finished devices,[3/] thus, U.S. shipments of piezoelectric crystals in 1978 were valued around $110 million. According to the U.S. Department of Commerce,

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[3/] Interview with Jack Clifford of U.S. Department of Commerce.

TABLE 3-4. MAJOR APPLICATIONS FOR ELECTRONIC CRYSTALS

TYPE OF CRYSTAL	MAJOR APPLICATIONS
Piezoelectric Crystals	
• Quartz	Timing devices in watches; frequency control, modulation, and demodulation in oscillators and filters
• Ceramic	Used in transducers, oscillators, ultrasonic cleaners, gas igniters, audible alarms, keyboard switches, medical electronics
• Yttrium-Iron-Garnet (YIG)	High-frequency control in microwave circuits for electronic devices such as sonar equipment.
Semiconducting Crystals	
• Silicon	Wafers for semiconductor devices such as integrated circuits, diodes, rectifiers, transistors and other circuit elements
• Gallium Arsenide, Gallium Phosphide	Light emitting diodes (LEDs) used as display devices in calculators, digital watches and other electronic equipment; high-performance transistors such as field effect transistors (FET)
• Indium Arsenide, Indium Antimonide	Components of power measuring devices
• Bismuth Telluride	Devices to cool small components of electrical circuits
• Sapphire	Substrate for silicon-on-sapphire (SOS) semiconductor devices; infrared detector cell windows; ultraviolet windows and optics; high power laser optics; ultracentrifuge cell windows
• Gallium-Gadolinium-Garnet (GGG)	Substrate for magnetic garnet films used in the manufacture of magnetic bubble memories
Liquid Crystals	Liquid crystal displays (LCDs) for calculators, digital watches, etc.

Source: EPA, *Final Development Document*

U.S. shipments of piezoelectric crystals had been growing slowly. The reason for this modest growth was the inability of U.S. companies to compete with the Japanese in several fast-growing markets such as those for electronic watch and CB radio crystals (for which the average annual growth rates between 1973 and 1978 were 26 and 24 percent respectively[4/]). As a result, U.S. firms are generally more specialized in the market for high performance crystals where foreign competition is not as strong. Although the number of devices that use these high-quality crystals has been increasing significantly, the demand for the crystals has been growing slowly because technological advances have reduced the number of crystals required in each device. For instance, the introduction of phase lock loop system has reduced the number of crystals used in communications equipment.[5/] U.S. Department of Commerce data show that U.S. shipments of crystal filters and frequency control devices fluctuated widely between 1973 and 1978, and averaged about 5 percent annual growth rate during that period (see Table 3-5). However, the validity of the data reported is very questionable, especially for earlier years.[6/]

It was estimated that the cost of a semiconductor wafer represented about 5 percent of the value of a semiconductor discrete device, and about 7 to 8 percent of the value of an integrated circuit.[7/] Based on the value of shipments of semiconductor devices reported in Table 3-6, the U.S. shipments of semiconducting and liquid crystals in 1979 were valued around $450 million. Between 1969 and 1979, the demand for semiconducting and liquid crystals had been growing rapidly as indicated by the 17 percent average annual growth rate of U.S. shipments of semiconductor devices (see Table 3-6).

[4/] U.S. Department of Commerce, U.S. Industrial Outlook 1980, p. 400.

[5/] Interview with Jack Clifford of U.S. Department of Commerce.

[6/] Ibid.

[7/] U.S. Department of Commerce, A Report on the U.S. Semiconductor Industry, September, 1979.

TABLE 3-5. U.S. SHIPMENTS OF PIEZOELECTRIC CRYSTAL DEVICES, 1973 - 1978 ($ MILLIONS)

Year	Frequency Control Devices	Filters	Total	Estimated Value of Crystal
1973	98.2	22.1	120.3	-
1974	90.6	29.9	120.5	-
1975	94.3	114.3	208.6	-
1976	143.3	76.9	220.2	-
1977	111.1	40.3	151.4	-
1978	107.1	41.5	148.6	110.0[a/]
AVERAGE ANNUAL COMPOUNDED GROWTH RATE[b/]	4.3%	10.1%	5.3%	

[a/] About 75 percent of value of finished devices (Interview with Jack Clifford of U.S. Department of Commerce).

[b/] Calculated using semi-log regression technique.

Source: U.S. Department of Commerce, Current Industrial Reports - Selected Electronic and Associated Products, Including Telephone and Telegraph Apparatus, selected issues.

TABLE 3-6. U.S. SHIPMENTS OF SEMICONDUCTOR DEVICES 1969 - 1979 ($ MILLIONS)

Year	Discrete Devices	Integrated Circuits	Total
1969	1013	480	1493
1970	987	594	1581
1971	870	696	1566
1972	1093	1268	2361
1973	1469	1709	3179
1974	1519	2056	3575
1975	1320	1718	3038
1976	1694	2598	4292
1977	1835	2697	4532
1978	1880	3950	5830
1979	1957	4671	6628
AVERAGE ANNUAL COMPOUNDED GROWTH RATE[a/]	8%	25%	17%

[a/] Calculated using semi-log regression technique.

Sources: U.S. Department of Commerce
Semiconductor Industry Association

3.5 FOREIGN TRADE

Data on U.S. imports and exports of electronic crystals are not available directly. However, the available evidence indicates that the U.S. manufacturers of semiconducting crystals seem to be able to successfully compete with their foreign producers. According to a Department of Commerce Report,[8/] many of the U.S. semiconductor device manufacturers have transferred their assembly operations overseas to take advantage of lower wage rates. However, these same companies still maintain the production of semiconductor wafers in the country. The primary reason for this is the capital intensive nature of the growing and fabricating process for wafers. However, this does not mean that there is no potential for competition from abroad. In fact, a number of firms in Japan and Europe have the necessary technology and capacity and, consequently, may serve to limit the ability of the domestic producers of semiconductor wafers to pass through the costs of environmental regulations.[9/]

For the manufacture of piezoelectric crystals, foreign competition is not expected to be too significant. As indicated earlier, the piezoelectric crystals currently produced by U.S. manufacturers are generally high-performance crystals and competition from foreign producers in this market does not seem to be very important. In the past, U.S. firms had tried to penetrate the booming market for quartz crystals for electronic watches and CB radios. However, aggressive competition from the Japanese producers, who now dominate the world market for these lower quality crystals, has driven most of these U.S. companies out of the market and forced them to specialize in the low-volume, high-quality crystal market instead.[10/]

[8/] U.S. Department of Commerce, A Report on the U.S. Semiconductor Industry, September 1979.

[9/] Interview with Jack Clifford of U.S. Department of Commerce.

[10/] *Ibid.*

4. BASELINE PROJECTIONS OF INDUSTRY CONDITIONS

This section provides projections of conditions in the U.S. electronic crystals industry to 1990 in the absence of further water pollution control requirements resulting from the Clean Water Act. The baseline projections in this report provide a general point of reference for the analysis and are not intended to be a comprehensive, authoritative forecast of future industry conditions. These projections provide a plausible picture of future developments, and thus can be used as a benchmark for comparison. The primary variables of interest are the industry's projected sales, capital requirements, and employment.

4.1 U.S. ELECTRONIC CRYSTAL SALES PROJECTIONS

As indicated in Table 3-5, shipments of piezoelectric crystals grew at a modest 5 percent average annual rate between 1973 and 1978. The U.S. Bureau of Mines projected that U.S. demand for lasca, a feedstock for growing cultured (i.e., artificial) quartz, will increase at an annual rate of approximately 3 percent through 1990. Since quartz crystal is the most common piezoelectric crystal and cultured quartz represents 95 percent of all electronic grade quartz, it is projected that U.S. annual production of piezoelectric crystals will grow about 3 percent a year and will total $130 million in 1983 and $160 million in 1990.1/ These projections are shown in Table 4-1.

U.S. production of semiconducting and liquid crystals is expected to grow more rapidly in the coming years. As summarized in Table 4-1, shipments of semiconductors by U.S. manufacturers were projected to be $11.3 billion for 1983 and $27.0 billion for 1990, up from $6.6 billion in 1979. Assuming that the crystals used in the manufacturing of semiconductor components would continue to be supplied mainly by domestic producers, U.S. production of semiconducting and liquid crystals is projected to grow from an estimated $450 million in 1979 to $770 million in 1983 and $1.84 billion in 1990.

1/ U.S. Bureau of Mines, Mineral Commodity Summaries 1981, pp. 120-121.

TABLE 4-1. PROJECTIONS OF U.S. ELECTRONIC CRYSTAL SHIPMENTS ($ MILLIONS)

Year	Piezoelectric Crystals	Semiconductor and Liquid Crystals	Semiconductors
1978 (Estimated)	110[a]	390[a]	5,830
1979 (Estimated)	(NA)	450[a]	6,628
1983 (Projected)	130[c]	770[d]	11,300[b]
1990 (Projected)	160[c]	1,840[d]	27,000[b]

(NA) = Not available

a/ JRB estimates (see Section 3.4).

b/ U.S. Department of Commerce forecasts (1983 U.S. Industrial Outlook).

c/ Assume 3 percent annual growth rate.

d/ Assume same growth rate as semiconductors.

Source: JRB Associates estimates

4.2 CAPITAL EXPENDITURES PROJECTIONS

Plants that produce semiconducting and piezoelectric crystals are classified under SIC 3674 (Semiconductors and Related Services) and SIC 3679 (Electronic Components, Not Elsewhere Classified), respectively. Between 1972 and 1977, annual capital expenditures of the plants under SIC 3674 ranged between 6 percent and 11 percent of the industry's value of shipments. A large share of the capital expenditures was for plant and equipment used in the manufacture of semiconductor devices which have experienced rapid obsolescence due to rapid changes in production technology. Since the manufacturing processes of crystals are not expected to change as rapidly, the annual capital expenditure rates are estimated to be lower and similar to those of the more stable segment of the industry, SIC 3679, which ranged from 3 percent to 5 percent between 1972 and 1977. For this reason, the annual capital expenditures rates were projected to average about 4 percent of the industry's value of shipments in the 1980s.

Table 4-2 below presents the projections of the capital expenditures required to maintain the projected levels of sales for the 1980s. It shows that new capital expenditure requirements in 1990 for the electronic crystal industry would be around $80 million.

TABLE 4-2. PROJECTIONS OF U.S. ELECTRONIC CRYSTAL INDUSTRY NEW CAPITAL EXPENDITURES ($MILLIONS)

Year	Industry Value of Shipments	Industry New Capital Expenditures
1983	900	40
1990	2,000	80

Source: JRB Associates estimates.

4.3 EMPLOYMENT PROJECTIONS

Based on EPA survey data, total employment in the industry was estimated at 10,000 in 1978. Since the manufacturing processes of electronic crystals are already very capital-intensive, it appears likely that the value of shipment per employee ratio would remain fairly stable in the 1980s.

Table 4-3 presents the projections of employment for the electronic crystal industry. The employment projections are based upon the ratio of value of shipments per employee and show that total employment in 1990 would be about 40,000.

TABLE 4-3. PROJECTIONS OF EMPLOYMENT IN THE U.S. ELECTRONIC CRYSTAL INDUSTRY

Year	Industry Value of Shipments ($Millions)	Industry Employment
1978	500	10,000
1983	900	18,000
1990	2,000	40,000

Source: JRB Associates estimates.

4.4 SUMMARY

Projections of conditions in the U.S. electronic crystal industry have been estimated in this section as a means of looking at future expectations. Our estimates show that by 1990, U.S. electronic crystal industry value of shipments will be $2 billion (an increase of $1.5 billion from 1978), industry new capital expenditures will be $80 million, and industry employment will be 40,000 (an increase of 30,000 from 1978).

5. COST OF COMPLIANCE

5.1 OVERVIEW

The recommended water treatment control systems, costs, and effluent limitations for the Electronic Crystals subcategory are enumerated in the Final Development Document for Effluent Limitation Guidelines for the Electrical and Electronic Components Point Source Category. This document identifies various characteristics of the industry, including manufacturing processes, products manufactured, raw waste characteristics, supply, volume, and discharge destination of water used in the production processes, sources of waste and wastewaters, and the constituents of wastewaters. Using that data, pollutant parameters requiring effluent limitations or standards of performance were selected by EPA.

The EPA Final Development Document also identifies and assesses the range of control and treatment technologies which apply to the Electronic Crystals subcategory. This assessment involved an evaluation of both in-plant and end-of-pipe technologies that could be designed for this subcategory. This information was then evaluated for existing direct dischargers to determine the effluent limitations achievable based on the best practical control technology currently available (BPT), and the best available technology economically achievable (BAT). Similar evaluations were performed for new direct dischargers to develop new source performance standards (NSPS). Finally, pretreatment standards for existing sources (PSES) and pretreatment standards for new sources (PSNS) were developed for dischargers to publicly owned treatment works (POTWs). The technologies identified were analyzed to calculate cost and performance of each. Cost data were expressed in terms of investment, operating and maintenance costs, depreciation, and interest expense.

5.2 POLLUTANT PARAMETERS

The selection of pollution parameters to be considered for regulation was based primarily on laboratory analyses of wastewaters sampled from several electronic crystals plants and responses to a mail survey of electronic crystals manufacturers. The specific approach to selecting the pollutant parameters was presented in Sections 5 and 6 of the Final Development Document. The specific pollutants selected for regulations are pH, total suspended solids (TSS), fluoride, total toxic organics (TTO), and arsenic. Arsenic is to be regulated only at facilities that produce gallium arsenide or indium arsenide crystals. The pollutants comprising TTO are listed in in the Final Development Document.

5.3 RECOMMENDED TREATMENT TECHNOLOGIES

Based on the analysis of the potential pollutant parameters and treatment-in-place in the electronic crystals industry, EPA identified six treatment technologies that are most applicable for the reduction of the selected pollutants. These treatment technologies are described in detail in Section 7 of the Final Development Document and are listed below:

- Option 1: Segregation and collection of spent solvents containing toxic organics for reuse, resale or contract hauling (referred to as solvent management) plus end-of-pipe treatment for pH control
- Option 2: Option 1 plus end-of-pipe precipitation/clarification for control of fluoride, arsenic, and suspended solids
- Option 3: Option 1 plus precipitation/clarification of concentrated fluoride wastes for control of fluoride
- Option 4: Option 2 plus recycle of treated effluent to further reduce pollutant discharges
- Option 5: Option 2 plus filtration to further reduce pollutant discharges
- Option 6: Option 5 plus activated carbon to further reduce toxic organics.

The Agency's evaluation of treatment options 4 and 6 concluded that these technologies would not be technically feasible for all crystal plants in the case of option 4, and would remove little, if any, pollutants in the case of option 6. For this reason, the economic impact analysis concentrated on treatment options 1, 2, 3, and 5 only.

5.4 TREATMENT COST ESTIMATES

Costs of compliance were estimated by EPA for treatment options 1, 2, 3, and 5. Treatment costs of option 1 are for monitoring costs only. Information available indicates that most electronic crystal plants are practicing some degree of solvent management to control toxic organics (53 percent of the plants are estimated to be already meeting the TTO limit), and that the incremental costs of disposal tend to be offset by resale of recovered solvent. Moreover, all these plants are controlling the pH of discharges by end-of-pipe neutralization.

The toxic organics monitoring costs are expected to apply to no more than approximately 50 percent of the plants in this subcategory because the regulation provides for a certification alternative to monitoring. EPA is unable to predict precisely which plants will incur monitoring costs; therefore, the economic impact was assessed for each plant. However, for purposes of estimating total compliance costs for this regulation, only half of these costs are included in the total since only half of the plants at most are expected to incur costs. Appendix I-A contains a sensitivity analysis on option 1 costs and economic impacts.

In developing the compliance cost estimates for treatment options 1, 2, 3, and 5 the following major assumptions were made by EPA:

- All costs are expressed in end-of-year 1979 dollars.
- The treatment facilities were assumed to operate 8 hours per day, 260 days per year for plants with discharge less than 60,000 gpd; 24 hours per day, 260 days per year for plants with 60,000 gpd to 200,000 gpd; and 24 hours per day, 350 days per year for plants with more than 200,000 gpd.
- Labor costs are based on an hourly rate of $20, including fringe benefits and plant overhead.
- The cost of land is valued at $12,000 per acre.
- Energy costs are based on $306 per horsepower.
- Sludge disposal costs are included. Available information indicates that the sludge to be disposed from the removal of fluoride is not defined as hazardous wastes by RCRA.

- The capital investment and annual operating and maintenance costs for monitoring the wastewater of a plant are \$2,000 and \$3,500 (based on an average sampling frequency of once every three months), respectively.

- Capital costs are amortized at 5 years and 13 percent interest.

5.4.1 Existing Sources

Based on the above assumptions, capital investment costs and annual compliance costs at several selected flow rates were estimated for treatment options 1, 2, 3, and 5. Chapter 9 in the Final Development Document present the cost curves for these options. These cost curves were used to estimate compliance costs for the seven model non-arsenide crystal plants and the eight actual arsenide crystal plants. The key operating characteristics of the seven model plants are summarized in Table 5-1. The seven model plants (non-arsenide crystal) were based on the plant sizes defined in Table 3-3, wastewater flow rates, and other data developed from the EPA 308 survey.

Information obtained by EPA indicates that all the identified non-arsenide direct dischargers are already in compliance with the alternative effluent standards. Tables 5-2 and 5-3 present the estimated investment and annual cost of compliance for the 53 non-arsenide indirect dischargers. Table 5-4 summarizes the compliance costs for the eight arsenide crystal plants.

5.4.2 New Sources

For the Electronic Crystal subcategory, the final NSPS and PSNS discharge limitations are the same as those for BAT and PSES. Since new source costs are defined as incremental costs from BAT and PSES, costs of NSPS and PSNS are zero.

TABLE 5-1. PROFILE OF NON-ARSENIDE METAL CRYSTAL MODEL PLANTS

Model Plants	Number of Employees	Flow Rate (GPD)	Value of Shipments ($000)	Profit Margin (%)	Book Value of Plant Assets ($000)
XS1. Extra Small Plant with Low Flow Rate	10	10	200	25	140
XS2. Extra Small Plant with High Flow Rate	20	150	300	20	220
S1. Small Plant with Low Flow Rate	80	65	2,000	25	1,200
S2. Small Plant with Medium Flow Rate	80	550	1,700	15	700
S3. Small Plant with High Flow Rate	80	5,000	1,700	15	700
M. Medium Plant	165	6,500	4,000	15	2,100
L. Large Plant	350	22,500	11,000	20	6,300

Source: JRB Associates estimates

TABLE 5-2. COMPLIANCE COSTS OF INDIRECT DISCHARGER NON-ARSENIDE METAL CRYSTAL MODEL PLANTS
(Thousand Dollars)

Plant Types	Flow Rate (GPD)	Compliance Capital Investment Per Plant				Annual Compliance Costs Per Plant			
		Option 1	Option 2	Option 3	Option 5	Option 1	Option 2	Option 3	Option 5
XS1	10	2.0	20.0	2.0	20.0	4.1	15.2	4.1	15.2
XS2	150	2.0	20.0	2.0	20.0	4.1	15.5	4.1	15.5
S1	65	2.0	20.0	2.0	20.0	4.1	15.2	4.1	15.2
S2	550	2.0	20.0	63.5	20.0	4.1	17.9	33.8	17.9
S3	5,000	2.0	102.6	63.5	116.0	4.1	72.3	52.5	80.2
M	6,500	2.0	114.1	63.5	127.9	4.1	80.6	52.5	88.7
L	22,500	2.0	189.0	103.7	207.6	4.1	135.9	85.2	146.8

Source: JRB Associates estimates

TABLE 5-3. TOTAL COMPLIANCE COSTS FOR 53 INDIRECT DISCHARGER NON-ARSENIDE CRYSTAL PLANTS
(Thousand Dollars)

Plant Types	Number of Sample Plants	Estimated Total Number Plants	Compliance Capital Investment[a/]				Annual Compliance Costs[a/]			
			Option 1*	Option 2	Option 3	Option 5	Option 1*	Option 2	Option 3	Option 5
XS1	4	5	5	95	5	95	10.3	65.8	10.3	65.8
XS2	3	4	4	76	4	76	8.2	53.8	8.2	53.8
S1	5	7	7	133	7	133	14.4	92.0	14.4	92.0
S2	5	7	7	133	438	133	14.4	110.9	222.2	110.9
S3	4	6	6	610	375	690	12.3	421.5	302.7	468.9
M	10	14	14	1,583	875	1,777	28.7	1,099.7	706.3	1,213.1
L	7	10	10	1,880	1,027	2,066	20.5	1,338.5	831.5	1,447.5
Total	38	53	53	4,510	2,731	4,970	108.8	3,182.2	2,095.6	3,452.0

[a/] Toxic organics monitoring costs are incurred by 50 percent of the plants only.

*Selected option

Source: JRB Associates estimates

TABLE 9-4. COMPLIANCE COSTS OF EIGHT ARSENIDE CRYSTAL PLANTS (Thousand Dollars)

Plant ID	Discharge Status	Number of Employees	Flow Rate	Value of Shipments	Compliance Capital Investment Option 1	Compliance Capital Investment Option 2*	Compliance Capital Investment Option 5	Annual Compliance Costs Option 1	Annual Compliance Costs Option 2*	Annual Compliance Costs Option 5
			(GPD)	($000)						
T1	Z	17	0	84	0	0	0	0	0	0
T2	Z	75	0	88	0	0	0	0	0	0
T3	I	6	1,250	600	0 a/	0 a/	0 a/	0 a/	0 a/	0 a/
T4	I	48	400	2,000	2.0 b/	2.0 b/	2.0 b/	4.1 b/	4.1 b/	4.1 b/
T5	I	42	7,200	2,384	2.0	118.9	132.8	4.1	84.1	92.3
T6	I	-	43,200	73,000	2.0	246.7	271.5	4.1	179.4	194.2
T7	I	300	135,000	45,000	2.0	393.3	449.7	4.1	292.8	323.0
T8	D	1,570	280,000	78,000 c/	0 a/	0 a/	0 a/	0 a/	0 a/	0 a/
Total					8.0	760.9	856.1	16.4	560.4	613.6
Indirect					8.0	760.9	856.1	16.4	560.4	613.6
Direct					0	0	0	0	0	0

*Selected Option.

na = Not available.

a/ This plant is already in compliance.

b/ This plant is already in compliance with fluoride and arsenic effluent standards. Only toxic organics need to be reduced through good solvent management techniques (see Final Development Document).

c/ Estimate based on number of employees.

Source: JRB Associates estimates

6. ECONOMIC IMPACT

This section provides an assessment of the economic impacts which are likely to occur as a result of the costs of the proposed effluent treatment technologies described in Chapter 5. It is based upon an examination of the estimated compliance costs and other economic, technical, and financial characteristics of both model and actual plants of various sizes and the analytical methodology described in Chapter 2. The primary economic impact areas discussed include changes in industry profitability, plant closures, substitution effects, changes in employment, shifts in imports and exports, etc.

6.1 PRICE AND QUANTITY CHANGES

As described in Chapters 2 and 3, the Electronic Crystals industry exhibits characteristics associated with non-competitive markets. For example, the industry has unusually high profit rates and most of the product groups have high concentration ratios and low demand elasticities. These three characteristics are often indicative of non-competitive markets. All other things being equal firms in this type of market would be able to recover part or all of the compliance costs in the form of higher prices.

However, as previously mentioned, the existence of the threat of foreign competition serves to mitigate the ability of firms in the industry to raise prices. Such price action would cause the domestic industry to lose market share. Consequently, it is assumed that there is an equilibrium trade-off between domestic and foreign market share which is determined largely by the price differentials; and that domestic producers would like to maintain the baseline equilibrium by maintaining the price spread between domestic and foreign producers. Since the domestic producers have high profit rates, they can afford to maintain the spread by absorbing the increased costs. For this reason, it is assumed that for small and moderate levels of compliance cost, domestic electronic crystals producers will absorb the costs and not adjust prices. Consequently, the price changes due to the regulations would be zero. It follows, also, that quantities demanded are not expected to change because of the regulations.

6.2 RESULTS OF SCREENING ANALYSIS

As described in Chapter 2, a ratio of annual compliance cost to plant revenues of one percent was used as a threshold value below which plants are considered to have low impacts from the regulations. The calculated ratios are shown in Table 6-1. Most non-arsenide model plants have compliance costs above this value for option 5. Therefore, the profitability analysis was conducted for all non-arsenide model plants. For the arsenide metal crystal plants only one plant (plant number T5) has compliance costs greater than one percent.

The one arsenide metal crystal plant and all of the non-arsenide plants were subjected to a more detailed analysis of plant profitability.

6.3 PROFIT IMPACT ANALYSIS

As indicated in Chapter 2 above, the assessment of the impact of compliance on plant profitability is based on the plants' after-compliance return on investment (ROI) ratios.

Table 6-2 summarizes the estimated profit impact for the seven non-arsenide model plants. As indicated in the table, there are significant reductions in ROI at some plants under options 2 and 5, smaller profit reductions under options 1 and 3. However, all non-arsenide model plants remain above the threshold level for profitability. Their after-compliance ROIs range between 18.5 percent and 39.7 percent at treatment option 5 as compared to 11.5 percent average yield of U.S. Treasury bonds for 1980[1/], and therefore are not considered to be potential plant closures.

Table 6-3 presents the estimated profit impact on the potential "high impact" arsenide metal crystal plant. This table indicates that after-compliance ROI under treatment options 2 and 5 are very low for plant T5. However, this plant is already operating at an extremely low ROI without the regulation, according to the responses to the EPA 308 survey. It is suspected that this low baseline ROI results from the internal transfer pricing of the respondent. Therefore, the baseline ROI is believed to be understated.

[1/] Standard and Poors Corp., The Outlook.

TABLE 6-1. SCREENING ANALYSIS

PLANT	ANNUAL COMPLIANCE COSTS TO VALUE OF SHIPMENTS (%)			
	Option 1	Option 2	Option 3	Option 5
Arsenide Crystals				
T1	0	0	NA	0
T2	0	0	NA	0
T3	0	0	NA	0
T4	0.2	0.2	NA	0.2
T5	0.2	3.5	NA	3.9
T6	*	0.8	NA	0.8
T7	*	0.7	NA	0.7
T8	0	0	NA	0
Non-Arsenide Crystals				
XS1	2.1	7.6	2.1	7.6
XS2	1.4	5.2	1.4	5.2
S1	0.2	0.8	0.2	0.8
S2	0.2	1.1	2.0	1.1
S3	0.2	4.3	3.1	4.7
M	0.1	2.0	1.3	2.2
L	*	1.2	0.8	1.3

NA = Not applicable. Treatment option not selected by EPA for this product group.

* Less than 0.05 percent.

Source: JRB Associates estimates.

TABLE 6-7. SUMMARY OF PROFIT IMPACT ASSESSMENT FOR NON-ARSENIDE CRYSTAL MODEL PLANTS

Model Plants	Value of Shipments	Assets Value	Pre-Compliance Return on Sales	Pre-Compliance ROI	After-Compliance ROI Option 1	After-Compliance ROI Option 2	After-Compliance ROI Option 3	After-Compliance ROI Option 5
	($000)	($000)	(%)	(%)	---------	--------(%)--------		---------
XS1	200	140	25.0	35.7	32.3	21.8	32.3	21.8
XS2	300	220	20.0	27.3	25.2	18.5	25.2	18.5
S1	2,000	1,200	25.0	41.7	41.3	39.7	41.3	39.7
S2	1,700	700	15.0	36.4	35.7	32.9	29.0	32.9
S3	1,700	700	15.0	36.4	35.7	22.8	26.5	21.4
M	4,000	2,100	15.0	28.6	28.3	23.5	25.3	22.9
L	11,000	6,300	20.0	34.9	34.8	31.8	33.0	31.6

Source: JRB Associates Estimates

TABLE 6-3. PROFIT IMPACT ASSESSMENT OF POTENTIAL "HIGH IMPACT" ARSENIDE CRYSTAL PLANTS

Plant ID	Value of Shipments ($000)	Assets Value ($000)	Pre-Compliance		After-Compliance ROI (%)		
			Return on Sales(%)	ROI(%)	Option 1	Option 2	Option 5
T5	2,384	4,800	4.0	2.0	1.9	0.2	0.1

Source: JRB Associates estimates

6.4 CAPITAL REQUIREMENTS ANALYSIS

As described in Chapter 2, the assessment of the firms' ability to raise the required capital is based upon ratios of compliance capital investment to revenues (CCI/R) for specific plants compared with the difference between the industry's highest and lowest ratios of average annual capital expenditures to average value of shipments between 1970 and 1977. The highest and lowest ratios for SIC 3679 (Electronic Components, n.e.c.) were 5.1 percent and 2.8 percent over the 1970-1977 time period respectively; [2] therefore, 2.3 percent was selected as the threshold level for the capital availability analysis. Plants whose CCI/R ratios are lower than 2.3 percent are considered to have low levels of impacts. Those plants with higher CCI/R ratios are subjected to the cash flow test described in Chapter 2.

Table 6-4 presents the compliance capital investment to plant revenue ratios for the non-arsenide crystal plants. As indicated in the table, compliance capital requirements for the proposed treatment options appear to be high for model plants XS1, XS2, S2, S3, and M. The cash flow test for these five plants is shown in Table 6-5. The plant annual cash flows (i.e., depreciation plus net profit after taxes) seem to be sufficient to meet total capital requirements (compliance capital investment plus minimum annual capital expenditures for plant and equipment) of all plants at each treatment option.

Table 6-6 summarizes the capital requirements analysis for the eight arsenide crystal plants, where plant T5 is predicted to have some difficulties financing treatment options 2 or 5. However, plant T5 is owned by a large integrated electronics company and the required compliance capital investments for both treatment options represent less than 0.1 percent of this firm's total annual capital expenditures in 1978.[3] Since the capital requirements is so small relative to total capital expenditures for this company, it is assumed that the company can readily finance the investment.

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[2] U.S. Department of Commerce, 1977 Census of Manufactures.

[3] Standard and Poor's Corp., Stock Market Encyclopedia.

TABLE 6-4. COMPLIANCE CAPITAL REQUIREMENTS ANALYSIS - NON-ARSENIDE CRYSTAL MODEL PLANTS

Model Plants	Value of Shipments ($000)	Assets Value ($000)	Pre-Compliance		Compliance Capital Investment to Value of Shipments (%)			
			Profit Margin(%)	ROI(%)	Option 1	Option 2	Option 3	Option 5
XS1	200	140	25.0	35.7	1.0	10.0*	1.0	10.0*
XS2	300	220	20.0	27.3	0.7	6.7*	0.7	6.7*
S1	2,000	1,200	30.0	50.0	0.1	1.0	0.1	1.0
S2	1,700	700	15.0	36.4	0.1	1.2	3.7*	1.2
S3	1,700	700	15.0	36.4	0.1	6.0*	3.7*	6.8*
M	4,000	2,100	15.0	28.6	0.1	2.9*	1.6	3.2*
L	11,000	7,200	20.0	34.7	**	1.7	0.9	1.9

* Greater than threshold value.

** Less than 0.05 percent.

Source: JRB Associates estimates

TABLE 6-5. COMPARISON OF CASH FLOW AND TOTAL CAPITAL REQUIREMENTS
(as a Percent of Plant Revenues)

Model Plants	Internally Generated Funds[a] (percent)	Total Capital Requirements[b]		
		Option 2	Option 3	Option 5
XS1	18.5	12.8	3.8	12.8
XS2	15.7	9.5	3.5	9.5
S2	11.1	4.0	6.5	4.0
S3	11.1	8.8	6.5	9.6
M	11.6	5.7	4.4	6.0

[a] Equivalent to net profit margin, (assuming an average corporate income tax rate of 40 percent) plus depreciation (10 percent of depreciable fixed assets, assumed to be 50 percent of total assets).

[b] Compliance capital investment plus minimum annual capital expenditures for plant and equipment to maintain a targeted production level (assumed to be 2.8 percent of plant revenues).

Source: JRB Associates estimates

TABLE 6-6. COMPLIANCE CAPITAL REQUIREMENTS ANALYSIS - ARSENIDE CRYSTAL PLANTS

Plant ID	Value of Shipments ($000)	Compliance Capital Investment To Value of Shipments (%) Option 1	Option 2	Option 5
T1	na	0	0	0
T2	na	0	0	0
T3	600	0	0	0
T4	2,000	0.1	0.1	0.1
T5	2,384	0.1	5.0[a/]	5.6[a/]
T6	23,000	*	1.1	1.2
T7	45,000	*	.9	1.0
T8	78,000[b/]	0	0	0

[a/] Compliance capital investment represents less than 0.1 percent of firm's total annual capital expenditures in 1978.

[b/] Estimate based on number of employees.

* Less than 0.05 percent.

Source: JRB Associates estimates.

6.5 POTENTIAL PLANT CLOSURES

Based on the profit impact assessment and capital requirements analysis discussed in Sections 6.2 and 6.3, only one arsenide crystal plant, model plant T5, might be considered to be a potential closure at treatment options 2 and 5. However, plant T5 is owned by a large integrated electronic company and supplies gallium arsenide and gallium phosphide crystals to be used in the production of LEDs at other production facilities of the firm. The plant's low reported baseline profitability may be due to the firm's intercompany transfer pricing policy and actual profit at market price may be very satisfactory. Therefore, it is expected that the firm will keep this plant operating to maintain control on the source of supply for its raw material.

6.6 EMPLOYMENT EFFECTS

The preceding section projects no closure potential for the proposed treatment technologies. Thus, no employment effects are expected from the promulgated regulations.

6.7 SUBSTITUTION EFFECTS

As described in Section 2.2, because of their special properties, the potential for substitution of electronic crystals in their current applications is limited in the base case. In addition, the preceding impact analysis assumes that there will be no price changes resulting from the proposed regulations. For these reasons, no substitution effects are expected to result from the promulgated regulations.

6.8 FOREIGN TRADE IMPACTS

As described in chapters 2 and 3, the United States is currently very competitive with foreign producers on the world market for electronic crystals. However, there exists considerable technical expertise among foreign producers, which is perceived as a potential source of competition. If there was a significant price effect from the regulations, the U.S. producers could lose market share. However, as indicated in the profit impact analysis described in Section 6.4, U.S. producers appear to be able and likely to absorb the additional pollution control costs. Consequently, no foreign trade impacts are expected to result from the regulations.

6.9 NEW SOURCE IMPACTS

As indicated in Section 5.4.2, the incremental costs of NSPS and PSNS are zero. Because there is no difference in compliance costs between existing and new sources, the regulations would not foster any competitive advantage or disadvantage between new and existing sources as long as treatment requirements for each are the same.

6.10 SUMMARY OF IMPACTS OF PROMULGATED REGULATIONS

The estimated economic impacts for the treatment options selected for promulgation in the Electronic Crystals subcategory are summarized in Table 6.7.

Toxic Organics

The control of toxic organics and pH under option 1 is not expected to cause any incremental compliance costs for non-arsenide crystal direct dischargers under BPT and BAT. These plants already control their discharges to the selected treatment level for regulation.

Non-arsenide crystal indirect dischargers are expected to incur monitoring costs to comply with the total toxic organics limitation under PSES. These costs, totaling $53,000 in capital investment and $109,000 in total annual costs, assume that at least the 50 percent of the plants already in compliance will choose to certify that they do not dump their solvents into the effluent instead of monitoring. The remaining plants are expected, on average, to monitor quarterly. Since the incremental costs of solvent disposal tend to be offset by resale of recovered solvent, EPA did not estimate costs for solvent management.

These monitoring costs are expected to cause moderate reductions in profitability for small non-arsenide crystal plants, but no plant closures are expected as a result of this level of control.

TABLE 6-7. SUMMARY OF ESTIMATED ECONOMIC IMPACTS

ECONOMIC IMPACT VARIABLES	OPTION 1	OPTION 2	OPTION 3	OPTION 5	SELECTED OPTION
Gallium/Indium Arsenide Crystals					
Annual Compliance Costs/Revenues (%)					
Indirect Dischargers	0-0.2	0-3.5	N/A	0-3.9	0-3.5
Direct Dischargers	0	0	N/A	0	0
Change in Price (%)	0	0	N/A	0	0
Change in Quantity (%)	0	0	N/A	0	0
Change in Profitability					
Indirect Dischargers	Low	Moderate	N/A	Moderate	Moderate
Direct Dischargers	0	0	N/A	0	0
Capital Requirements					
Indirect Dischargers	Low	Moderate	N/A	Moderate	Moderate
Direct Dischargers	0	0	N/A	0	0
Plant Closures due to Regulations	0	0	N/A	0	0
Employment at Closed Plants	0	0	N/A	0	0
Balance of Trade Changes	None	None	N/A	None	None
Industry Structure Changes	None	None	N/A	None	None
Non-Arsenide Crystals					
Annual Compliance Costs/Revenues (%)					
Indirect Dischargers	0-2.1	0.8-7.6	0.2-3.1	0.8-7.6	0-2.1
Direct Dischargers	0	0	0	0	0
Change in Price (%)	0	0	0	0	0
Change in Quantity (%)	0	0	0	0	0
Change in Profitability					
Indirect Dischargers	Moderate	Signif.	Moderate	Signif.	Moderate
Direct Dischargers	0	0	0	0	0
Capital Requirements					
Indirect Dischargers	Low	Moderate	Moderate	Moderate	Low
Direct Dischargers	0	0	0	0	0
Plant Closures due to Regulations	0	0	0	0	0
Employment at Closed Plants	0	0	0	0	0
Balance of Trade Changes	None	None	None	None	None
Industry Structure Changes	None	None	None	None	None

N/A = Not applicable. Treatment option not selected by EPA for this product group.

In addition to the above analysis, EPA conducted a sensitivity analysis for option 1 costs consisting of two parts. First, the impact of monthly monitoring was estimated for all facilities (some facilities may monitor as frequently as once per month, although EPA cannot identify precisely which ones.) In addition to this analysis, costs and impacts were also determined for facilities which may incur "worst case" solvent disposal costs. These costs are developed for facilities that could fall under the requirements of the Resource Conservation and Recovery Act (RCRA) for disposal. The analysis of these costs shows that while the effects on profitability are higher using these costs, the effects are not expected to significantly increase the impact on these facilities and are not expected to cause any plant closures.

Arsenic

Three arsenide crystal plants are expected to incur investment costs of $761,000 and $560,000 annually (including monitoring) as a result of the control of arsenic under option 2 for PSES. One arsenide crystal plant shows relatively high impacts under this control. However, this plant is owned by a large electronics company and supplies crystals to be used in the production of LEDs at other production facilities of the firm. It is expected that the firm will keep this plant operating to maintain control of the source of supply for its raw material. Consequently, no plant closure is expected.

New Sources

The effluent standards and associated technologies for new sources are identical to those for existing sources. Consequently, the economic impacts for new sources will mirror those of existing sources and the promulgated regulations are not expected to foster competitive advantages or disadvantages between new and existing sources.

7. SMALL BUSINESS ANALYSIS

The Regulatory Flexibility Act (RFA) of 1980 (P.L. 96-354) requires Federal regulatory agencies to consider "small entities" throughout the regulatory process. The RFA requires an initial screening analysis to be performed to determine if a substantial number of small entities will be significantly impacted. If so, regulatory alternatives that eliminate or mitigate the impacts must be considered. This analysis addresses these objectives by identifying and evaluating the economic impacts of the aforementioned regulations on small electronic crystal manufacturers. As described in Chapter 2, the small business analysis is developed as an integral part of the general economic impact analysis and is based on the examination of the distribution by plant size of the number of electronic crystal plants, plant revenues, wastewater volumes, compliance costs and potential closures from the regulations.

As explained in Chapter 2, in the absence of a specific definition for a small electronic crystal business, three plant size definitions based on plant revenues were used to provide the EPA possible alternative definitions of small electronic crystal manufacturing operations. These are:

- Plants with less than $1 million in value of shipments
- Plants with less than $3 million in value of shipments
- Plants with less than $5 million in value of shipments.

The number of electronic crystals plants falling into each size category is shown in Tables 7-1 and 7-2 for the arsenide and non-arsenide crystal plants, respectively. The tables also show the plant revenues of the different sized plants, along with the percentages of the industry total for each. As the tables show, the industry is characterized by a few large plants which account for most of the production and many smaller plants producing a smaller portion of industry output.

The information available for this study precluded a forecast to the 1985-1990 period of change in the distribution of industry output by plant

Table 7-1. SUMMARY OF SMALL BUSINESS ANALYSIS
FOR ARSENIDE CRYSTAL PLANTS

	All	Plants with Annual Revenues (in millions)			
	Plants[a]	<1	1 - 3	3 - 5	> 5
No. of Plants - Number	4	0	2	0	2
- % of Total			50.0		50.0
Flow rate - 000 gpd	185.8	0	7.6	0	178.2
- % of Total			4.1		95.9
Plant Revenues - %					
- $ million	72.4	0	4.4	0	68.0
- % of Total			6.1		93.9
Treatment Option 1 Costs					
Investment - $000	8	0	4	0	4
- % of Total			50.0		50.0
Annual - $000	16	0	8	0	8
- % of Total			50.0		50.0
- % of Revenues	*		0.2		*
Treatment Option 2 Costs					
Investment - $000	761	0	121	0	640
- % of Total			15.9		84.1
Annual - $000	560	0	88	0	472
- % of Total			15.7		84.3
- % of Revenues	0.8		2.0		0.7
Treatment Option 5 Costs					
Investment - $000	856	0	135	0	721
- % of Total			15.8		84.2
Annual - $000	614	0	97	0	517
- % of Total			15.8		84.2
- % of Revenues	0.8		2.2		0.8

[a] Four arsenide crystal plants are already in compliance and are excluded from this analysis.

*Less than .05 percent.

Source: JRB Associates estimates.

TABLE 7-2. SUMMARY OF SMALL BUSINESS ANALYSIS FOR NON-ARSENIDE CRYSTAL PLANTS

	All Plants	Plants with Annual Revenues (in millions) <1	1 - 3	3 - 5	> 5
No. of Plants - Number	53	9	20	14	10
- % of Total		17.0	37.7	26.4	18.9
Flow Rate - 000 gpd	351.0	0.7	34.3	91.0	225.0
- % of Total		0.2	9.8	25.9	64.1
Plant Revenues -					
- $ Million	204.3	2.2	36.1	56.0	110.0
- % of Total		1.1	17.7	27.4	53.8
Treatment Option 1 Costs					
Investment - $000	53	9	20	14	10
- % of Total		17.0	37.7	26.4	18.9
Annual - $000	109	19	41	29	20
- % of Total		17.4	37.6	26.6	18.[illegible]
- % of Revenues	0.5	0.9	0.1	0.1	*
Treatment Option 2 Costs					
Investment - $000	4,510	171	876	1,583	1,880
- % of Total		3.8	19.4	35.1	41.7
Annual - $000	3,182	120	624	1,100	1,338
- % of Total		3.8	19.6	34.6	42.1
- % of Revenues	1.6	5.5	1.7	2.1	1.2
Treatment Option 3 Costs					
Investment - $000	2,731	9	820	875	1,027
- % of Total		0.3	30.0	32.0	37.6
Annual - $000	2,096	19	539	706	832
- % of Total		0.9	25.7	33.7	39.7
- % of Revenues	1.0	0.9	1.5	1.3	0.8
Treatment Option 5 Costs					
Investment - $000	4,970	171	956	1,777	2,066
		3.4	19.2	35.8	41.6
Annual - $000	3,452	120	672	1,213	1,447
- % of Total		3.5	19.5	35.1	41.9
- % of Revenues	1.7	5.5	1.9	2.2	1.3

*Less than .05 percent.

Source: JRB Associates estimates.

size. However, no reason was found to expect the proportion of industry output produced by these small plants to change. For these reasons, the assessment of impacts on small business were developed from the data on existing plants.

The assessment of economic impacts on small plants begins with an evaluation of compliance costs incurred at the plant level. Tables 7-1 and 7-2 also show the estimated investment and total annual compliance cost for electronic crystal manufacturing by plant size. These tables also show the proportion of electronic crystal output and industry compliance costs attributed to both small and large plants. For example, at treatment option 2 the nine non-arsenide crystal plants with less than $1 million in revenues discharge only 0.2 percent of the total wastewater discharged while they account for 4.2 percent of total annual compliance costs. In contrast to these small plants, the ten plants with sales greater than $5 million discharge 64.1 percent of the wastewater and incur only 41.3 percent of total annual compliance costs. For all regulatory options, compliance cost as a percent of revenues is significantly larger for the smaller than for the larger plants.

Because the compliance costs of small plants are greater than that of larger plants and because they compete for the same markets as larger plants, their profits as measured by return on assets would decrease more than those of larger plants. Likewise, their capital requirements for compliance relative to their revenues will be greater than that of larger plants. However, as shown in Chapter 6, the magnitude of these impacts for the selected options are not enough to cause any closures or any other significant impact among these smaller plants. Consequently, there will be no employment, community impacts, or industry structure changes resulting from the regulations.

As described in Chapters 2 and 6, the regulations will not cause changes to the prices of electronic crystals. As a result, manufacturers will absorb the full amount of the compliance costs and, therefore, will experience lower profits from electronic crystal manufacturing.

8. LIMITATIONS OF THE ANALYSIS

This section discusses the major limitations of the economic impact analysis. It focuses on the limitations of the data, methodology, assumptions, and estimations made in this report. Information pertaining to the estimation of the compliance costs for specific plants and its limitations are outlined in Section 9 of the EPA Development Document.

The economic impacts assessed are the result of this regulation only. The assessment does not include the economic impacts associated with other regulations for air pollution control, OSHA requirements, and solid waste requirements.

8.1 DATA LIMITATIONS

The accuracy of the conclusions of this report depends largely on the accuracy of the data used in the analyses, especially that of the estimated compliance costs, and plant financial and economic characteristics.

A critical data input to this study is the compliance cost estimates. The compliance costs used were developed from compliance cost curves provided by EPA. The assumptions relating to the estimation of compliance costs are outlined in Section 9 of the EPA Development Document and summarized in Section 5.4 of this report.

In addition to the compliance cost assumptions, plant financial profiles used in the analysis are subject to the following major assumptions and limitations:

- Baseline financial data of the eight existing arsenide crystal plants are obtained from EPA 308 survey and follow-up telephone interviews with plant representatives;
- Plant characteristics such as size and flow rate of the 53 non-arsenide crystal plants are inferred from survey data collected by EPA on 38 existing plants;
- Baseline financial data of the 53 non-arsenide crystal plants are inferred from survey data on 26 plants;

- The impact analysis for non-arsenide crystal plants was based on seven model plants which were developed from the above survey data; and
- Plant financial data are based on 1978 economic conditions and will remain essentially the same over the period of the study.

Because individual plant financial characteristics vary from the model plant profiles, the model plants developed for this study should be considered order of magnitude estimates of the typical operating characteristics of the non-arsenide crystals manufacturing industry. However, it is believed that the sample of plants was sufficient to reflect considerable intra-industry variations in conditions. Therefore, although the confidence interval of the conclusions are indeterminate, there is no reason to suspect that the conclusions are biased toward overestimating or underestimating the degree of potential impact.

8.2 METHODOLOGY LIMITATIONS

In addition to the data limitations described above, this report is also subject to the following limitations of the methodology used:

- It is assumed that firms will not attempt to pass through the compliance costs to their customers by raising their product prices;
- The required rate of return on investment (i.e., profit impact threshold value) is estimated to be 11.5 percent, the 1980 average yield of U.S. Treasury bonds;
- The threshold values of a firm's capital availability are assumed to be the plant's estimated annual cash flow and/or the industry historical annual rates of capital expenditures as reported by the Census of Manufactures; and
- Plant closure criteria do not include the financial structure of the plants, and the time value of money, or special plant-specific conditions.

8.2.1 Price Increases Assumption

The analysis assumes that the electronic crystals industry will not increase the price of their products and pass through any portion of the compliance costs to their customers. While this is a reasonable assumption for some types of crystals it may not be true for the entire industry. It is possible that the price pass-through percentage will vary among the various types of crystals. Adequate information on these segments is not available. Therefore, no further analysis is carried out to measure the extent of a price increase which may occur as the production costs of the plants increase with the installation of pollution control.

The estimation error which might result from the price change assumptions depends primarily on the cross elasticity of demand with respect to the ratio of domestic to foreign prices. That is, if increased domestic prices shifts demand production overseas, there would be a drop in aggregate quantities produced by domestic producers and, consequently, unemployment, and possibly other impacts. Thus, the remaining domestic crystal producers would have healthy profits, but account for a smaller portion of world market share. On the other hand, if such shifts were smaller, then domestic producers could raise prices to cover compliance expenditures without losing market share.

If the latter situation prevailed in the real world, the economic impacts estimated in this report are overstated. If the former situation prevailed, the impacts would take a different form, but would probably not exceed the levels estimated in Chapter 6 of this report.

8.2.2 Profit Impact Threshold Assumptions

The profit impact assessment is determined by comparing the plant's after compliance return on investment (ROI) to the average yield of U.S. Treasury bonds which is 11.5 percent in 1980. Plants with after-compliance ROI below 11.5 percent are assumed to be potential plant closures.

Although investment decisions based on discounted cash flow techniques generally provide more consistent and theoretically correct investment decisions than those based on ROI analysis, ROI analysis is widely used by the investment community and does provide acceptable results in comparative analyses of industry-wide conditions, such as that presented in this report. It is reasonable to assume that plants cannot continue to operate as viable concerns if they are unable to generate a ROI that is at least equal to the opportunity cost of other lower risk investment alternatives (e.g , U.S. Treasury bonds).

8.2.3 Capital Availability Threshold Assumptions

A firm's ability to make the required pollution control investment is evaluated by comparing the required compliance capital investment to the industry historical annual rates of capital expenditures and the plant's estimated internally generated annual cash flow. Although the above analyses do not precisely indicate whether or not firms can afford to make the investments, they do provide a good indication of the relative burden created by the compliance requirement.

8.2.4 Plant Closure Assessment

The criteria for plant closure are not all inclusive. They do not address the financial structure of the plants, the time value of money, or other factors which affect closure decisions. A more detailed closure analysis would require more precise data on the capital structure, and cash flow of plants in the electronic crystals industry. However, the costs of the recommended treatment technology are small, and a more detailed analysis will not necessarily yield different results.

8.3 SUMMARY OF LIMITATIONS

Although a number of assumptions and data limitations may significantly bias the economic impact conclusions, the potential changes to the conclusions resulting from the elimination of these biases are probably small. Sensitivity analyses of plus and minus 20 percent were performed for each of the above assumptions. These analyses concluded that if each of the aforementioned variables changed by plus or minus 20 percent, there would be no plant closures as a result of the regulations and the other results of the study would not be significantly impacted. Consequently, the conclusions of this study appear to represent a reasonable industry-wide assessment of potential impacts.

APPENDIX I-A
SENSITIVITY ANALYSIS ON OPTION I COSTS

I. INTRODUCTION

The costs used to analyze the economic impact of option 1 in the crystals subcategory analysis are based on two assumptions: (1) that the only costs associated with compliance consist of toxic organics monitoring costs, and (2) that monitoring will occur, on average, once per quarter for the affected plants. This analysis consists of two parts. The first part estimates the economic impact of monthly monitoring on individual plants in place of the quarterly monitoring. The second part estimates the economic impacts of "worst case" incremental solvent disposal costs.

II. MONITORING COST SENSITIVITY ANALYSIS

EPA estimates that facilities covered under this regulation will, on average, monitor their effluent for toxic organics once per quarter. However, some facilities may monitor as frequently as once per month. Because EPA cannot determine precisely which facilities will be required to monitor on a monthly basis, this analysis is performed for all plants to determine the impact of the costs associated with more frequent monitoring.

The capital investment cost required for monitoring monthly is the same as that for monitoring quarterly, $2,000. The annual operating and maintenance (O&M) costs for quarterly monitoring are $3,500 (as reported in Chapter 5); therefore, the annual O&M costs for monthly monitoring are $10,500 (quarterly costs times 3).

The methodology for analyzing the impacts of monthly monitoring is the same as described in Chapter 2 of this report. Tables A-1 through A-3 summarize the results of this analysis. For the non-arsenide plants, the costs of monthly monitoring have some effect on profitability, with reductions in the return on investment (ROI) ranging from 0.2 to 8.3 percentage points

TABLE A-1. ESTIMATED COMPLIANCE COSTS BASED ON ANNUAL MONITORING COSTS OF $11,000 PER PLANT[a]

PLANT	ANNUAL COMPLIANCE COSTS PER PLANT ($000)			
	OPTION 1	OPTION 2	OPTION 3	OPTION 5
Arsenide Crystals				
T1	0	0	NA	0
T2	0	0	NA	0
T3	0[b]	0[b]	NA	0[b]
T4	11.1[c]	11.1[c]	NA	11.1[c]
T5	11.1	91.1	NA	99.3
T6	11.1	186.4	NA	201.2
T7	11.1	299.8	NA	330.0
T8	0[b]	0[b]	NA	0[b]
Non-Arsenide Crystals (Model Plants)				
XS1	11.1	22.2	11.1	22.2
XS2	11.1	22.5	11.1	22.5
S1	11.1	22.2	11.1	22.2
S2	11.1	24.9	40.8	24.9
S3	11.1	79.3	59.5	87.2
M	11.1	87.6	59.5	95.7
L	11.1	142.9	92.2	153.8

NA = Not applicable. Treatment option not selected by EPA for this product group.

a/ Include $10,500 annual O&M costs and $600 annual capital cost.

b/ This plant is already in compliance.

c/ This plant is already in compliance with fluoride and arsenic effluent standards. Only toxic organics need to be reduced through effective solvent management techniques (see Final Development Document).

SOURCE: JRB Associates estimates.

TABLE A-2. SCREENING ANALYSIS BASED ON ANNUAL MONITORING COSTS OF $11,000 PER PLANT[a/]

PLANT	ANNUAL COMPLIANCE COSTS TO VALUE OF SHIPMENTS (%)			
	OPTION 1	OPTION 2	OPTION 3	OPTION 5
Arsenide Crystals				
T1	0	0	NA	0
T2	0	0	NA	0
T3	0	0	NA	0
T4	0.6	0.6	NA	0.6
T5	0.5	3.8	NA	3.9
T6	*	0.8	NA	0.9
T7	*	0.7	NA	0.7
T8	0	0	NA	0
Non-Arsenide Crystals				
XS1	5.6	11.1	5.6	11.1
XS2	3.7	7.5	3.7	7.5
S1	0.6	1.1	0.6	1.1
S2	0.7	1.5	2.4	1.5
S3	0.7	4.7	3.5	5.1
M	0.3	2.2	1.5	2.4
L	0.1	1.3	0.8	1.4

NA = Not applicable. Treatment option not selected by EPA for this product group.

[a/] Include $10,500 annual O&M costs and $600 annual capital costs.

* Less than 0.05 percent.

SOURCE: JRB Associates estimates.

TABLE A-3. SUMMARY OF PROFIT IMPACT ASSESSMENT BASED ON ANNUAL MONITORING COSTS OF $11,000 PER PLANT[a/]

PLANT	VALUE OF SHIPMENTS	ASSETS VALUE	PRE-COMPLIANCE		AFTER-COMPLIANCE ROI			
			RETURN ON SALES	ROI	OPTION 1	OPTION 2	OPTION 3	OPTION 5
	($000)	($000)	(%)	(%)	--------------------(%)--------------------			
Arsenide Crystals								
T5	2,384	4,800	4.0	2.0	1.8	0.1	NA	-0.1
Non-Arsenide Crystals								
XS1	200	140	25.0	35.7	27.4	17.4	27.4	17.4
XS2	300	220	20.0	27.3	22.0	15.6	22.0	15.6
S1	2,000	1,200	25.0	41.7	40.7	39.2	40.7	39.2
S2	1,700	700	15.0	36.4	34.7	32.0	28.1	32.0
S3	1,700	700	15.0	36.4	34.7	21.9	25.6	20.6
M	4,000	2,100	15.0	28.6	28.0	23.1	25.0	22.6
L	11,000	6,300	20.0	34.9	34.7	31.7	32.9	31.4

NA = Not applicable. Treatment option not selected by EPA for this product group.

a/ Include $10,500 annual O&M costs and $600 annual capital costs.

SOURCE: JRB Associates estimates.

(Table A-3). However, these reductions are not expected to cause reductions in production or plant closures because the ROIs remain above the ROI threshold level (see Chapter 2). One arsenide plant, T5, appears to have a relatively large reduction in ROI, from 2.0 percent to 0.1 percent for the selected option 2 (which includes the monthly monitoring costs). However, as explained in Chapter 5, this plant is owned by a large, integrated electronics firm. The low pre-compliance ROI is likely the result of transfer-pricing within the company that understates the profits at this plant. We believe that this plant is likely to continue to operate despite this low profitability, to maintain control of supplies to the downstream plants in the company.

Thus, while the impact of monthly monitoring is expected to be greater than for quarterly monitoring, the impacts are not expected to cause plant closures.

III. SOLVENT DISPOSAL SENSITIVITY ANALYSIS

EPA has determined that the incremental costs associated with improved solvent management techniques tend to be offset by resale of the solvents. Consequently, EPA did not cost out any small costs for the purposes of the impact analysis. However, some facilities may have to haul away their solvents under the requirements of the Resource Conservation and Recovery Act (RCRA). This analysis examined "worst case" costs for all plants under RCRA hauling because EPA cannot determine which plants, if any, will fall under these requirements. These costs are not considered to be ordinary or average costs of compliance for facilities in this industry.

EPA estimated individual plant costs for each facility where possible. For remaining plants, and for model plants, the costs were extrapolated from plants with similar volumes of spent solvents. The costs used in the impact analysis appear in Table A-4.

TABLE A-4. ESTIMATED COMPLIANCE COSTS ASSUMING INCURRENCE OF SOLVENT DISPOSAL COSTS

PLANT	ANNUAL COMPLIANCE COSTS PER PLANT ($000)			
	OPTION 1	OPTION 2	OPTION 3	OPTION 5
Arsenide Crystals				
T1	0	0	NA	0
T2	0	0	NA	0
T3	0[a]	0[a]	NA	0[a]
T4	12.0[b]	12.0[b]	NA	12.0[b]
T5	12.0	92.0	NA	100.2
T6	12.0	187.3	NA	202.1
T7	12.0	300.7	NA	330.9
T8	0[a]	0[a]	NA	0[a]
Non-Arsenide Crystals				
XS1	12.0	23.1	12.0	23.1
XS2	12.0	23.4	12.0	23.4
S1	12.0	23.1	12.0	23.1
S2	12.0	25.8	41.7	25.8
S3	12.0	80.2	60.4	88.1
M	12.0	88.5	60.4	96.6
L	12.0	144.8	94.1	155.7

NA = Not applicable. Treatment option not selected by EPA for this product group.

a/ This plant is already in compliance.

b/ This plant is already in compliance with fluoride and arsenic effluent standards. Only toxic organics need to be reduced through effective solvent management techniques (see Final Development Document).

SOURCE: JRB Associates estimates.

The impact analysis was performed including the costs of monthly monitoring. This was done to determine the maximum possible impact on any one plant assuming that (1) the plant is required to monitor toxic organics monthly; and (2) the plant must dispose its spent solvents under RCRA.

The analysis followed the methodology described in Chapter 2 of this report. Table A-5 shows the results of the screening analysis, and Table A-6 summarizes the results of the sensitivity analysis. The profit reductions and levels are only slightly different than with monthly monitoring costs alone. For the non-arsenide plants, the costs of monthly monitoring plus RCRA solvent disposal have some effect on profitability, with reductions in ROI ranging from 0.2 to 8.9 percentage points. These reductions are not expected to cause reductions in production or plant closures because the ROIs remain above the threshold level. The one arsenide plant with a relatively high impact, T5, is not expected to close because it is owned by a large, integrated electronics firm which uses the products for its "downstream" process facilities.

Thus, while the impact of monthly monitoring plus RCRA solvent disposal costs are greater than quarterly monitoring costs alone, the impacts are not expected to cause plant closures.

TABLE A-5. SCREENING ANALYSIS ASSUMING INCURRENCE OF SOLVENT DISPOSAL COSTS

PLANT	ANNUAL COMPLIANCE COSTS TO VALUE OF SHIPMENTS (%)			
	OPTION 1	OPTION 2	OPTION 3	OPTION 5
Arsenide Crystals				
T1	0	0	NA	0
T2	0	0	NA	0
T3	0	0	NA	0
T4	0.6	0.6	NA	0.6
T5	0.5	3.9	NA	4.2
T6	0.1	0.8	NA	0.9
T7	*	0.7	NA	0.7
T8	*	0	NA	0
Non-Arsenide Crystals				
XS1	6.0	11.6	6.0	11.6
XS2	4.0	7.8	4.0	7.8
S1	0.6	1.2	0.6	1.2
S2	0.7	1.5	2.5	1.5
S3	0.7	4.7	3.6	5.2
M	0.3	2.2	1.5	2.4
L	0.1	1.3	0.9	1.4

NA = Not applicable. Treatment option not selected by EPA for this product group.

* Less than 0.05 percent.

SOURCE: JRB Associates estimates.

TABLE A-6. SUMMARY OF PROFIT IMPACT ASSESSMENT ASSUMING INCURRENCE OF SOLVENT DISPOSAL COSTS

PLANT	VALUE OF SHIPMENTS	ASSETS VALUE	PRE-COMPLIANCE		AFTER-COMPLIANCE ROI			
			RETURN ON SALES	ROI	OPTION 1	OPTION 2	OPTION 3	OPTION 5
	($000)	($000)	(%)	(%)	(%)	(%)	(%)	(%)
Arsenide Crystals								
T5	2,384	4,800	4.0	2.0	1.7	0.1	NA	-0.1
Non-Arsenide Crystals								
XS1	200	140	25.0	35.7	26.8	16.8	26.8	16.8
XS2	300	220	20.0	27.3	21.6	15.3	21.6	15.3
S1	2,000	1,200	25.0	41.7	40.6	39.1	40.6	39.1
S2	1,700	700	15.0	36.4	34.6	31.8	27.9	31.8
S3	1,700	700	15.0	36.4	34.6	21.8	25.5	20.5
M	4,000	2,100	15.0	28.6	28.0	23.1	24.9	22.6
L	11,000	6,300	20.0	34.9	34.7	31.7	32.9	31.4

NA = Not applicable. Treatment option not selected by EPA for this product group.

SOURCE: JRB Associates estimates.

PART II

SEMICONDUCTOR SUBCATEGORY

1. INTRODUCTION

1.1 PURPOSE

The purpose of this report is to analyze the economic impacts that may result from the promulgation of EPA's effluent regulations on the semiconductor industry subcategory of the Electrical and Electronic Products point source category. The effluent standards and limitations which are issued under Section 301(b) of PL 92-500, the Clean Water Act of 1977, require the Administrator (EPA) to establish the following:

1. Effluent limitations based on the Best Practicable Technology Currently Available (BPT), Best Conventional Pollutant Control Technology (BCT), or Best Available Technology Economically Achievable (BATEA or BAT) to be met by industrial dischargers
2. Pretreatment standards for existing and new dischargers (PSES and PSNS) to publicly owned treatment works (POTWs)
3. New Source Performance Standards (NSPS) to be met by new source industrial dischargers.

In order to assist in the development of these limitations this study explicitly assesses the effects of various pollution abatement regulatory options upon the costs of production, capacity expansion and replacement, profitability, and the potential for plant closures in the semiconductor industry. In addition, the likely effects on employment, communities, foreign trade, and small businesses are estimated.

1.2 SCOPE

The semiconductor subcategory as defined for this study includes the manufacture of electronic components made from elements such as silicon and germanium that contain small amounts of impurities which make them neither good electrical conductors nor good insulators. Among other functions, semiconductors can amplify, switch, and rectify electronic current. They are increasingly used in place of vacuum tubes or electron receiving tubes, mechanical relays, switches, and ferromagnetic memory coils (in computers). Semiconductors are used in many electrical and electronic products, such as radio and television receivers, and in transmitters, amplifiers, calculators, computers, auto ignitions, telephone switching systems, cameras, and digital watches.

The industry can be segmented into four separate product classes. These product classes and their associated standard industrial classification (SIC) codes are shown below.

SIC	INDUSTRY PRODUCT CLASS
3674	Semiconductor and Related Devices
36741	Integrated Microcircuits
36742	Transistors
36745	Diodes and Rectifiers
36749	Semiconductor Devices, n.e.c., and parts

The semiconductor industry includes both discrete or individual function devices such as diodes, rectifiers, and transistors; and integrated circuits, including both monolithic (which may contain hundreds or thousands of transistors and diodes on a single chip 1/4 inch square) and hybrid integrated circuits (on which discrete semiconductors have been attached). Also included in this industry are such specialized devices as light-emitting diodes (used as the display device in many calculators and digital watches) and light sensitive devices (such as photo diodes). Moreover, there are thousands of different kinds of diodes, transistors, and integrated circuits within each of these groups.

1.3 ORGANIZATION OF PART II OF THIS REPORT

The remainder of Part II of this report is organized in the following manner. Chapter 2 provides the methodology used to analyze the economic impacts of the regulations. Chapter 3 describes the semiconductor industry characteristics and performance in the domestic and international markets. Chapter 4 provides projections of the growth and performance of the semiconductor industry over the regulatory impact period assuming there are no additional water pollution control requirements. In Chapter 5 the costs of pollution control for the treatment options are presented. Chapter 6 presents the results of the economic impact assessment. Finally, Chapter 7 discusses the limitations of the economic impact analysis.

2. STUDY METHODOLOGY

2.1 OVERVIEW

Figure 2-1 shows an overview of the analytical approach used to assess the economic impacts likely to occur as a result of the costs of each proposed regulatory option. For the Semiconductor subcategory, four regulatory options are considered in the economic impact study. The basic approach used in this study is to (1) develop an operational description of the price and output behavior of the industry, and (2) assess the likely plant-specific responses to the incurrence of the compliance costs enumerated in Chapter 5.

The operational description of the price and output behavior is used, in conjunction with compliance cost estimates supplied by EPA, to determine new post-compliance industry price and production levels for each regulatory option. Individual plant data is then analyzed under conditions of the post-compliance industry price levels, for each regulatory option, to isolate those plants whose production costs are projected to change significantly more than the estimated change in their revenues. These identified plants are subjected to a more detailed financial analysis to determine likely plant closures. The industry description is then revised, for each regulatory option, to incorporate the reduced supply into the analysis. Finally, other effects which flow from the basic price, production, and industry structure changes are determined. These include employment, community, and foreign trade impacts. Specifically, the study proceeds in the following steps:

1. Description of industry characteristics
2. Industry supply and demand analysis
3. Analysis of cost of compliance estimates
4. Plant level profitability analysis
5. Plant level capital requirements analysis
6. Assessment of plant closure potential
7. Assessment of other impacts
8. Small business analysis.

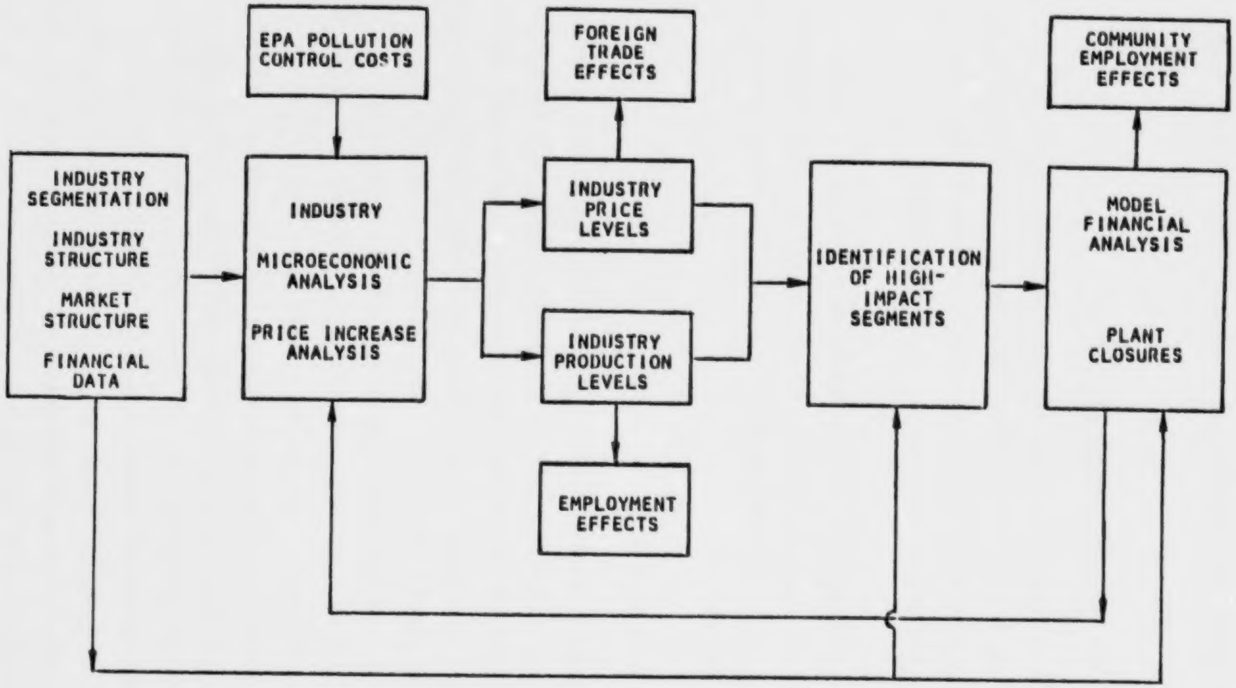
EPA POLLUTION CONTROL COSTS
FOREIGN TRADE EFFECTS
COMMUNITY EMPLOYMENT EFFECTS
INDUSTRY SEGMENTATION
INDUSTRY STRUCTURE
MARKET STRUCTURE
FINANCIAL DATA
INDUSTRY
MICROECONOMIC ANALYSIS
PRICE INCREASE ANALYSIS
INDUSTRY PRICE LEVELS
INDUSTRY PRODUCTION LEVELS
IDENTIFICATION OF HIGH-IMPACT SEGMENTS
MODEL FINANCIAL ANALYSIS
PLANT CLOSURES
EMPLOYMENT EFFECTS

FIGURE 2-1. ECONOMIC ANALYSIS STUDY OVERVIEW

Although each of these steps is described separately in this section, it is important to realize that there are significant interactions between them, as shown in Figure 2-1.

2.2 STEP 1: DESCRIPTION OF INDUSTRY CHARACTERISTICS

The first step in the analysis is to describe the basic industry characteristics. These characteristics, which include the determinants of demand, market structure, the degree of intra-industry competition, and financial performance, are described in Chapter 3 of this report.

The sources for this information include government reports, trade association data, discussions with various trade association representatives and individuals associated with the industry, and an EPA industry survey under Section 308 of the Clean Water Act.

2.3 STEP 2: SUPPLY-DEMAND ANALYSIS

The purpose of the supply-demand analysis is to determine the likely changes in market prices and industry production levels resulting from each regulatory option. The estimates of post-compliance price and output levels are used in the plant-level analysis to determine post-compliance revenue and profit levels for specific plants in each product group. If prices are successfully raised without significantly reducing product demand and companies are able to maintain their current financial status, the potential for plant closings will be minimal. If prices cannot be raised to fully recover compliance costs because of the potential for a significant decline in product demand or because of significant intra-industry competition, the firms may attempt to maintain their financial status by closing higher cost/less efficient plants. The supply-demand analysis was divided into four basic components: description of industry structure, determination of industry pricing mechanism, projection of possible changes in industry structure during the 1980s (when the primary economic impacts of the regulations will be felt), and determination of plant- and firm-specific operational parameters (e.g., production costs, profit rates, etc.).

Short-run pricing behavior depends upon the market structure of the industry, which can range from competitive, to oligopoly, and to monopoly situations. Many economic impact studies begin by assuming perfect competition. However, the product groups covered in this study exhibit some characteristics that are indicative of non-competitive pricing mechanisms.

The perfectly competitive market structure is one in which there are many buyers and sellers and the actions of any one of these do not significantly affect the market. Firms in a competitive market generally earn a "normal" rate of return on their assets. If it is assumed that (1) the market for a competitive good is currently at equilibrium, or will be when the regulations become effective, and (2) firms will attempt to maintain their current financial status by passing through industry-wide cost increases in the form of higher prices, the post-compliance equilibrium price and quantity level can be derived from the interaction of the elasticities of supply and demand.

Because of the existence of speciality markets, non-competitive pricing behavior might be expected. In this situation, a number of pricing schemes may be used to characterize the behavior of oligopolistic firms, depending on specific industry characteristics. The oligopolistic pricing scheme is applicable for those industry groups which exhibit characteristics of oligopoly markets, such as the following:

- Few firms in the product group
- High industry concentration
- Low degree of foreign competition
- Abnormally high profitability
- Low demand elasticities
- Highly capital intensive
- Large degree of integration of production, marketing, and distribution
- Large degree of specialized knowledge.

Industries which exhibit the first three of these characteristics are those in which the pricing and output actions of one firm will directly affect those of other firms in the industry. While these conditions do not guarantee oligopolistic behavior, they are necessary conditions for an oligopoly and good indicators that one exists. Abnormally high profits in an industry would, in time, normally attract new entrants to the industry, thereby increasing price competition. However, very high profits over long periods of time which are not explained by such factors as excess risk, unusual amounts of technological innovation, or firm size may be an indicator that an imperfect market structure exists. Such conditions may occur when entry into an industry is difficult. The last three of the above points are indicators of difficulty of entry into the market.

Although the domestic semiconductor industry exhibits some of these characteristics of non-competitive markets, the specific nature of the pricing mechanism is not clear from the available evidence. That is, the existence of specialty markets, low-demand elasticities, and high levels of specialized knowledge characteristic of this industry are indicative of non-competitive markets. On the other hand, there are a number of characteristics which are indicative of competitive markets, such as the existence of many firms in the industry, a significant amount of competition from foreign producers, and the fact that barriers to entry into the industry are not particularly severe. Little can be concluded from the four-firm and eight-firm concentration ratios, because they are in a middle (moderate) range. For these reasons and because of the dynamic nature of this new industry, the pricing mechanisms that dominate the industry cannot be specified with certainty. Instead, it is assumed that semiconductor plants will attempt to absorb all of the costs of compliance and that in the short to intermediate period there will be no change in semiconductor prices resulting from the regulations. This assumption derives from two observations:

- The international competitiveness in the industry has been increasing in recent years and domestic manufacturers are quite sensitive to this fact.

- If, at any point in time, it were possible to determine profit rates attributable to different semiconductor product lines within a given plant, there would probably be a wide variation in the profit rates.

The U.S. semiconductor manufacturers operate in a very competitive world market. There is significant trade and competition among the western developed nations for market share. Consequently, U.S. producers cannot unilaterally attempt to pass additional regulatory costs through to their customers without losing significant portions of the domestic and international markets. If they do atttempt to pass through the pollution control costs, the U.S. products would become less competitive, forcing domestic and foreign purchasers to buy semiconductor products in foreign markets that do not have these added costs. As U.S. products became more expensive, imports of semiconductor products into the U.S. would increase, exports would decrease, and sales and profitability of U.S. plants would significantly decrease as U.S. producer prices rose. Since U.S. semiconductor producers are quite sensitive to these conditions, their most likely option would be to absorb the regulatory costs in the short and intermediate period and continue operations if possible.

The existence of differences in profits from one product line to another within a firm implies the potential for price flexibility. That is, the most mature product lines operating with narrow profit margins may have some of their compliance cost burden borne by the most profitable newer products. For this reason, there generally exists within the industry the capability for absorbing the cost of the pollution control equipment.

In summary, although the market structure is not precisely determined, it has been shown that the industry has both the incentive and the capability to not raise prices in response to small and moderate levels of mandated pollution control costs. For these reasons, it is assumed that there will be no price effect resulting from the proposed regulations in the short and intermediate time period.

The remainder of the economic impact analysis, therefore, focuses on the extent that plants in the semiconductor industry can remain financially viable and competitive if they are required to install pollution control equipment. The measures of financial viability that are considered relate to the plants' profitability and their ability to raise the initial investment funds for pollution control equipment in addition to other capital equipment needed for expansion, growth, and competitiveness.

Having described the current industry structure, it was necessary to determine if the key parameters would change significantly during the 1980s. Projections of industry conditions begin with a demand forecast. The demand during the 1980s is estimated via trend analysis and market research analysis. The projections of industry conditions indicated that only minor changes in market structure would occur in the base case. For this reason, it was concluded that the market structure previously described can be used to determine price changes due to the regulation.

The post-compliance market price levels (i.e., zero price increases due to the regulation) are used in a later step to assess the financial condition of individual semiconductor manufacturing facilities.

2.4 STEP 3: COST OF COMPLIANCE ESTIMATES

Investment and annual compliance costs for the recommended treatment options 1, 2, 3, and 5 were estimated by EPA's Effluent Guidelines Division for treatment systems of various selected sizes. Based on these cost estimates, compliance cost curves were developed and then used to estimate plant-specific compliance costs. A description of the control and treatment technologies and the rationale behind these compliance cost estimates appear in Chapter 5.

2.5 STEP 4: PLANT LEVEL PROFITABILITY ANALYSIS

The basic measure of financial performance used to assess the impact of the proposed regulations on the profitabilities of individual plants is return on sales (ROS). The use of this technique involves a comparison of the after compliance ROS with a critical return.

The return on sales is defined as the ratio of annual profits before taxes to the total revenues of a plant. The principal virtue of this technique is its simplicity and its common use in comparative analyses of operating efficiencies of financial entities. Its principal shortcomings are that it is based on accounting income rather than cash flow and that it fails to account for the amount of invested capital and the timing of cash flows, thereby ignoring the time value of money.

The profit impact assessment is determined by calculating the after-compliance ROS for each plant and comparing them to a threshold value which represents the lowest ROS which the industry typically considers to be acceptable to remain in operation. Plants with after-compliance ROS below the threshold value are considered potential plant closures. The underlying assumption is that plants cannot continue to operate as viable concerns if they are unable to generate a return on sales that is at least equal to the threshold value. Equation (1) summarizes this technique:

$$(1) \quad PM - \frac{ACC_p}{VS_p} \leq PM_L \quad \text{Significant Profit Impact}$$

where

PM = the pre-compliance average annual profit margin (ROS) for the industry

PM_L = the lowest ROS at which plants will remain open

$\frac{ACC_p}{VS_p}$ = the ratio of the total annual compliance costs (ACC_p) to annual value of shipments (VS_p) for each plant.

The lowest acceptable PM was determined to be 2.7 percent. This figure was derived from the observation that it is the lowest annual profit margin for the semiconductor industry over the 1971-1977 period.[1/] The precompliance profit margin is curved to be 4.5 percent, which is the average for the 7-year period. Since 2.7 percent is the lowest ROS recorded by operating plants, it is assumed to be a rather conservative threshold.

[1/] U.S. Department of Commerce, U.S. Semiconductor Industry, September 1979.

The values of shipments for the 21 sample plants were estimated by multiplying the industry average value of shipments per production employee by the number of production employees working at the specific sample plant. The industry average value of shipments per production employee was derived from the 1977 Census of Manufactures. The value of shipments data along with the total annual compliance cost estimates are used to analyze the performance of the plants after compliance.

2.6 STEP 5: CAPITAL REQUIREMENTS ANALYSIS

This step in the analysis assesses the ability of firms to make the initial capital investment needed to construct and install the required treatment systems. Some plants which are not initially identified as potential closures in the profitability analysis may encounter problems raising the amount of capital required to install the necessary treatment equipment. The limit on a given firm's ability to raise capital to finance investment expenditures is quite variable, depending upon factors such as the firm's capital structure, profitability, future business prospects, the industry's business climate, the characteristics of the financial markets and the aggregate economy, and the firm management's relationships with the financial community. The precise limit, considering all these factors, is ultimately judgmental. Thus, even given firm-specific data, a limit on a firm's ability (or willingness) to raise funds for capital investment would be difficult to estimate. Because firm-specific data for this study is scarce the problem becomes even more difficult. For these reasons, the analysis of capital availability focused upon general indicators of the relative burden created by the compliance expenditures for each semiconductor firm. That is, to assess the firms' ability to commit the capital necessary to install the specified pollution control systems, the following ratio is calculated for each sample plant:

$$\frac{\text{Compliance Capital Investment}}{\text{Annual New Plant and Equipment Expenditures}}$$

This ratio reflects the typical level of capital expenditures of the industry, and is used as a budget standard of the capital expenditure level that firms in the industry generally hold. Although a specific threshold value for this parameter is difficult to specify, a value that is useful for comparison is the average annual value of this ratio for the entire industry.

Although this ratio provides a good indication of the relative burden created by the compliance requirement, it does not precisely indicate whether or not firms can afford to make the investments. If, for example, the same investment requirements were placed on a firm which is already highly leveraged (as indicated by a high debt/equity ratio) and a firm which is not leveraged (as indicated by a debt/equity ratio of zero), the highly leveraged firm is likely to experience the most significant impact. In addition, the capital requirements must be evaluated together with other factors, such as profitability. For example, a plant that is extremely profitable would consider the risk of more leverage or increased cost of capital resulting from investment more worthwhile than would a less profitable plant.

Because of the absence of plant-specific financial data, the annual capital expenditures of the plants are inferred from the industry average new capital expenditures per production employee ratios.2/ These annual capital expenditure estimates, along with capital investment cost for the pollution control options, are used to indicate the significance of the capital impacts.

2.7 STEP 6: PLANT CLOSURE ANALYSIS

The plant-level analysis examined the individual production units in each product group to determine the potential for plant closures and profitability changes. The decision to close a plant, like most major investment decisions, is ultimately judgmental. This is because the decision involves a wide

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2/These ratios are derived from the 1977 Census of Manufactures.

variety of considerations, many of which cannot be quantified or even identified. Some of the most important factors are:

- Profitability before and after compliance
- Ability to raise capital
- Market and technological integration
- Market growth rate
- Other pending Federal, state, and local regulations
- Ease of entry into market
- Market share
- Foreign competition
- Substitutability of the product
- Existence of specialty markets.

Many of these factors are highly uncertain, even for the owners of the plants. However, this analysis was structured to make quantitative estimates of the first two factors, as described above, and to qualitatively consider the importance of the others. In this analysis, the first two factors are given the greatest amount of weight and the importance of the other factors varies from plant to plant.

2.8 STEP 7: OTHER IMPACTS

"Other impacts" include economic impacts which flow from the basic price, production, and plant-level profitability changes. These include impacts on employment, communities, industry structure, and balance of trade.

The estimate of employment effects flows directly from the outputs of the industry-level analysis and the plant closure analysis. The algorithms used are:

$$\begin{array}{c}\text{direct}\\ \text{employment}\end{array} = \begin{array}{c}\text{employment at}\\ \text{closed facilities}\end{array} + (\ S_r)/(S/\text{employee})$$

S_r = change in revenues at the remaining plants, which is derived from the microeconomic and plant level analyses (in this case $S_r = 0$).

S/employee = baseline revenue produced per employee.

Employment estimates for the production facilities projected to close are available from the EPA 308 Survey.

Community impacts result primarily from employment impacts. The critical variable is the ratio of semiconductor industry unemployment to total employment in the community. Data on community employment are available through the Bureau of the Census and the Bureau of Labor Statistics.

The assessment of industry structure changes is based on examination of the following before and after compliance with the regulation:

- Numbers of firms and plants
- Industry concentration ratios
- Effects of plant closures on specialty markets.

Imports and exports are important determinants of pricing behavior in the semiconductors industry. The role of these variables is qualitatively evaluated in Chapter 3 of this report. Basically, the threat of imports appears to deter domestic producers from passing through compliance costs.

2.9 STEP 8: SMALL BUSINESS ANALYSIS

The Regulatory Flexibility Act (RFA) requires Federal regulatory agencies to consider small entities throughout the regulatory process. This analysis addresses thess objectives by identifying and evaluating the economic impacts that are likely to result from the promulgation of BPT, BCT, BATEA, NSPS, PSES and PSNS regulations on small business in the semiconductor manufacturing industry. The primary economic variables covered are those analyzed in the general economic impact analysis such as plant financial performance, plant closures, and unemployment and community impacts. Most of the information and analytical techniques in the small business analysis are drawn from the general economic impact analysis which is described above and in the remainder of this report. The specific conditions of small firms are evaluated against the background of general conditions in semiconductor markets.

A specific problem in the methodology was developing an acceptable definition of small entities. The Small Business Administration (SBA) defines small entities in SIC 3674 (Semiconductors and Related Devices) and SIC 3679 (Electronic Components, n.e.c.) as firms of fewer than 500 employees. The SBA definition was found to be inappropriate as a basis for defining small entities in the semiconductor manufacturing industry for purposes of developing water pollution regulations. Instead, a definition was sought which would account for firm size in comparison to total industry size and in comparison to unit compliance costs (unit compliance costs increase significantly in reverse proportion to plant size). Moreover, since the available data on compliance cost and production were on a plant basis, the individual production facility, rather than the firm, was used as the basis for the analysis.

Alternative definitions for "small" semiconductor manufacturing plants were selected for examination. Number of production employees was the primary variable used to distinguish plant size. This is because plant level employment data were considered most reliable.

The impacts on small plants under each definition were assessed by examining the distribution of semiconductor plants by plant employee size, wastewater volumes, compliance costs and potential closures from regulations.

3. INDUSTRY DESCRIPTION

This chapter provides an overview of the semiconductor industry. It describes the economic and market characteristics of the industry and the factors that contribute to the growth of the industry. Particular attention is given to the demand and end-use markets for semiconductor products. Additionally, information is provided on the industry structure, foreign competition, and price trends because these factors determine the future outlook and competitiveness of the industry, and producers' ability to afford additional capital outlays for pollution control equipment.

3.1 MARKET CHARACTERISTICS

3.1.1 Major Product Groups and Trends

In 1982, the value of shipments for all semiconductor devices in the U.S. domestic industry was $9.5 billion (Table 3-1). This represented an increase of 5 percent over the 1981 level of shipments. The economic downturn over 1981-1982 was responsible for the slow growth over this period. Historically, this industry has experienced very high rates of growth. During the 1970s, the semiconductor industry grew at a compound annual rate of about 19 percent, which was substantially higher than the 12 percent annual growth experienced during the 1960s. Moreover, for some segments such as integrated circuits, shipments have grown by about 18.3 percent annually, over the 1972-1982 period. This industry segment's rapid growth, however, has been at the expense of other semiconductor devices, such as discrete resistors and capacitators, which it has displaced in many types of equipment.

The recent penetration of integrated circuits into the semiconductor market is reflected in the fact that while integrated circuits accounted for 54 percent of the domestic market share in 1972, they represented 72 percent by 1982. In contrast, the discrete devices segment of the market has been

TABLE 3-1. VALUE OF SHIPMENTS OF THE U.S. SEMICONDUCTOR INDUSTRY
1972 - 1982
($ Millions)

YEAR	SEMICONDUCTOR PRODUCTS		
	DISCRETE DEVICES	INTEGRATED CIRCUITS	TOTAL SEMICONDUCTORS
1972	1,093	1,268	2,361
1977	1,835	2,697	4,532
1979	2,696	4,660	7,356
1980	2,687	6,768	9,455
1981[a/]	2,576	6,500	9,076
1982[a/]	2,719	6,820	9,539

[a/] Estimated.

SOURCE: U.S. Department of Commerce, U.S. Industrial Outlook 1983.

increasing at a much slower rate and has been losing its market share over the years. In 1972 the market share of this industry segment was 46 percent, but by 1982 it had dropped to 28 percent of total industry shipments. If new applications for discrete devices, such as those used in automotive engines, had not been introduced, the decreases in market share for this industry segment could have been even greater.

3.1.2 End-Use Markets

Since the invention of semiconductor devices in the late 1950s, their uses have pervaded almost every sector of our society. The principal end-uses of semiconductor devices can be grouped into four major market categories:

- Computer
- Industrial
- Consumer
- Government, including military/space.

The growth of the semiconductor industry depends on the performance of each of these end-use markets. The semiconductor industry end-use markets, with few exceptions, have been outperforming the general economy in recent years. The relative strength of these end-use markets is derived from the integrated and pervasive role which electronic components (specifically semiconductors) play in all sectors of the economy. These end-use markets are expected to continue to grow in the future.

The relative growth of these four markets is shown in Table 3-2. Each of these markets has experienced different historical development patterns due to the relative trade-offs between performance, reliability, and cost of semiconductors in product applications.3/ For example, component costs are far more important in highly competitive consumer product industries than in other markets. Computer and industrial equipment manufacturers require high-performance

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3/ U.S. Department of Commerce, A Report of the U.S. Semiconductor Industry, September 1979.

TABLE 3-2. DISTRIBUTION OF SEMICONDUCTOR PRODUCTS BY MAJOR END-USERS (1973 - 1975)

End-Users	1973 ($mil.)	% of Total	1974 ($mil.)	% of Total	1975 ($mil.)	% of Total	Percent Change		
							72/73	73/74	74/75
Computer	$590	28	$855	32	$1,005	33	66	45	18
Industrial	605	29	775	30	905	29	54	28	17
Consumer	510	25	575	22	715	23	72	13	24
Government, inc. military/space	378	18	420	16	450	15	26	11	7
TOTAL	$2,083	100	$2,625	100	$3,075	100	55	26	17

SOURCE: Fairchild Camera and Instrument Corp., cited in "Coleman and Company Electronics Letter," B. M. Rosen, March 8, 1974.

and reliable components, and price is of lesser importance than in consumer products. The military/space market has very high performance and reliability requirements and is willing to pay for the development of premium products. Semiconductor devices used in military and space applications must be capable of operating under extreme weather and other adverse conditions. This market also requires specialized, high-performance semiconductors, such as infrared detectors, radiation detection devices, and light-sensing devices, which have very limited civilian applications. Because they are spread over a small production volume, unit development and production costs are high.

3.2 INDUSTRY STRUCTURE

3.2.1 Plant Characteristics

The 1977 Census of Manufacturers reported 545 establishments whose primary activity is the manufacture of semiconductors.[4/] In that year, these plants shipped over $5.3 billion worth of products. Table 3-3 provides information on the distribution of plants in the industries by their employee size classifications and value of shipments. This table indicates that the industry is composed of a disproportionately large number of very small and medium-sized plants, and the number of these plants has been increasing at a faster rate than large plants. However, the larger plants are responsible for most of the semiconductor products shipped. For example, plants that had over 500 employees shipped 79 percent of the products in 1977, but they represented only 7.5 percent of the plants in the total industry. The information shown in the table also indicates that the plants in the semiconductor industry are highly specialized. That is, approximately 94 percent of their product shipments were semiconductor devices in 1977. Furthermore, the average coverage ratio for the industry is high. In 1977, 545 plants in the industry manufactured 93 percent of the products classified under SIC 3674.

[4/] A significant number of these plants, especially the smaller ones, may be R&D and other facilities that are not necessarily involved in wafer manufacturing and are not covered by the proposed regulation.

TABLE 3-3. DISTRIBUTION OF SEMICONDUCTOR PLANTS AND VALUE OF SHIPMENTS BY SIZE OF PLANT

(Selected Years)

PLANT SIZE	SEMICONDUCTOR INDUSTRY (SIC 3674)							
	PLANTS (No.)		PLANTS a/ (Percentage)		VALUE OF SHIPMENTS (Millions)		VALUE OF a/ SHIPMENTS (Percentage)	
	1972	1977	1972	1977	1972	1977	1972	1977
Establishments with:								
1 - 99 employees b/	225	414	69.0	76.0		263.3	4.9	4.4
100 - 499 employees	65	90	20.0	16.5		860.0	14.4	16.2
500 - 999 employees	17	19	5.2	3.5		529.5	10.4	10.0
Over 1,000 employees	18	22	5.5	4.0		3696.8	70.3	69.4
Total	325	545	100.0	100.0		5349.6	100.0	100.0
Coverage Ratio c/							92.0	94.0
Specialization Ratio d/							89.0	93.0

a/ Percentage of total sampled plants within each employment category of the total plants.

b/ A number of these plants, especially the smaller ones, may be R&D and other facilities that are not necessarily involved in wafer manufacturing.

c/ Coverage ratio is the ratio of a given industry's primary product shipments to total shipments of this product by all industries.

d/ Specialization ratio is the ratio of primary product shipments to total primary and secondary product shipments.

SOURCE: U.S. Department of Commerce, Bureau of Census, Census of Manufactures, 1977, Industry Series: Electronic Components and Accessories, MC77-1-36E (Washington, D.C. 1980).

As shown in Table 3-4, the plants of the U.S. domestic semiconductor industry are concentrated in a few states. In 1977, approximately a third of the plants were located in California, and over two-thirds were located in six states: California, New York, Massachusetts, New Jersey, Pennsylvania, and Texas. Most of the largest semiconductor companies have several domestic plants (usually in the same region of the country) and several foreign plants. In many cases, increases in the number of plants in a particular firm have been the result of growth in the industry's market and limitations in adjacent land needed to enlarge the size of existing plants. This phenomenon is especially true in the northern California area where the scarcity of large industrial tracts has influenced companies to build many plants on different sites. In some cases semiconductor companies have also constructed plants that specialize in the production of specific products. For example, a semiconductor company may have an integrated circuit plant and a separate transistor and diode plant, or separate MOS and bipolar integrated circuit plants.

3.2.2 Industry Concentration

The semiconductor industry has shown a consistent level of market share concentration over time. In 1972, the four largest manufacturers of semiconductors provided half of the industry's total value of shipments, only 1 percent lower than in 1957. Table 3-5 indicates that firms that produce transistors are more highly concentrated than firms in other semiconductor product groups. In 1972, the concentration ratio for the largest four companies producing transistor products was 68 percent, as opposed to 57 percent for firms in the integrated circuits, and 45 percent for those in the diodes and rectifiers product groups.

3.3 FOREIGN TRADE

The market for semiconductors is worldwide. The United States is a significant exporter and importer of semiconductor devices. It is important to note that most large and many of the smaller U.S. semiconductor companies conduct the design and wafer fabrication processes in the United States and

TABLE 3-4. GEOGRAPHICAL DISTRIBUTION OF DOMESTIC SEMICONDUCTOR PLANTS IN 1977[a]

STATE	NUMBER OF ESTABLISHMENTS	NUMBER OF ESTABLISHMENTS WITH 20 OR MORE EMPLOYEES
New England Division:		
Maine	3	1
Vermont	2	1
Massachusetts	46	23
Rhode Island	4	2
Connecticut	13	6
Middle Atlantic Division:		
New York	59	22
New Jersey	34	11
Pennsylvania	31	16
East North Central Division:		
Ohio	13	5
Indiana	5	2
West North Central Division:		
Minnesota	3	1
Missouri	4	1
South Atlantic Division:		
Florida	19	9
East South Central Division:		
Tennessee	1	1
West South Central Division:		
Oklahoma	3	1
Texas	36	16
Mountain Division:		
Idaho	1	1
Colorado	8	3
Arizona	16	9
Utah	3	1
Pacific Divison:		
Oregon	4	2
California	180	80
Total U.S.	545	219

[a] The totals do not add up because of lack of state-specific information.

SOURCE: U.S. Bureau of the Census, Census of Manufactures, 1977, Industry Series: Electronic Components and Accessories, MC77-1-36E (Washington, D.C., 1980).

TABLE 3-5. CONCENTRATION RATIOS OF U.S. DOMESTIC SEMICONDUCTOR SHIPMENTS 1957, 1965, AND 1972 (PERCENT OF TOTAL U.S. DOMESTIC SHIPMENTS)[a]

NUMBER OF COMPANIES	PERCENT OF TOTAL U.S. SHIPMENTS 1957	1965	1972
All semiconductors			
4 largest companies	51	50	50
8 largest companies	71	77	66
20 largest companies	97	90	81
50 largest companies	100	96	96
Integrated circuits			
4 largest companies		69	57
8 largest companies		91	73
20 largest companies		99	91
50 largest companies		100	100
Transistors			
4 largest companies		51	68
8 largest companies		83	84
20 largest companies		95	98
50 largest companies		100	100
Diodes and Rectifiers			
4 largest companies		38	45
8 largest companies		56	61
20 largest companies		85	88
50 largest companies		97	100

[a] Data include value of production in captive facilities.

SOURCE: Compiled from data collected in the Department of Commerce, Quarterly Survey of Production Capabilities for Electronic Parts.

then ship the chips abroad to Southeast Asia or Mexico for wire bonding and assembly. After assembly, the devices are imported back into the United States subject to special U.S. tariff provisions. These tariff provisions specify that goods shipped abroad for assembly and then shipped back to the United States shall be subject to duty only on the value added abroad.

Japan is one of our most important trading partners for finished semiconductors, particularly for integrated circuits. Its growing equipment and components industries have become a major market for U.S. semiconductors and also a major supplier of semiconductor containing products to this country.

According to the Department of Commerce, the U.S. exports of semiconductor devices rose 5.1 percent in 1982, to $3.65 billion. Imports increased 7.3 percent, to $3.81 billion. During the 1972-1982 period, exports grew at a compound annual rate of 22.8 percent and imports at a rate of 27.7 percent. Exports as a proportion of product shipments rose from 19.9 percent to 38.8 percent, while imports rose from 12.3 percent of new supply to 28.6 percent. The import growth reflects an increase in U.S. offshore operations and competition from Japan, particularly in the random access memory (RAM) segment of the semiconductor industry.

In recent times, the Japanese have made significant inroads into the high-quality and technologically advanced markets of the semiconductor industry. They have already captured 40 percent of the market for the 16K chip, and are considered the leaders in the 64K RAM market.5/ Key factors that contributed to the Japanese technological advancements in these areas, which were traditionally dominated by U.S. firms, are the Japanese's high level of manufacturing discipline, team effort, and long-range planning capabilities. If these trends continue, the balance of trade position for semiconductor products will deteriorate as U.S. electronic manufacturers use increasingly more of the Japanese low-priced, high-quality semiconductor products.

5/ Fortune, Japan's Ominous Chip Victory, December 14, 1981, pp. 52-57.

3.4 PRICING BEHAVIOR AND TRENDS

Since their introduction in the marketplace, there has been a downward trend in the prices of semiconductor devices. This downward trend is illustrated in Table 3-6, which shows price indexes for major groups of semiconductor products over the 1975-1980 period. This table indicates that the prices of three of the four product groups declined over this period. The only price increases are in the discrete segment of the industry (diodes and rectifiers) which represents a much slower growing and mature segment of the semiconductor industry.

There are several reasons for the decline in prices of semiconductor devices over the years. Some of the major factors contributing to this phenomenon are the following:

- The life cycle of most semiconductor products is short. The products pass from sales of prototypes through market expansion to a technologically mature product in only a few years. Price reductions are generally very rapid during the market expansion phase. The prices tend to fall most rapidly on those new devices for which there has been new entry by several firms or for new devices which can be easily imitated.

- Competition and trade in both the domestic and international markets are strong. As a result, high profits on new products generally lead to new entry by firms that, in turn, cause prices to fall. Semiconductor firms also recognize that large price drops may slow or prevent new firms from entering the industry, and they use price cuts to retain or increase their market share.

- In addition, the learning or experience curve appears to have a strong influence on the downward trend in prices of this industry. The experience curve theory implies that as the cumulative output increases by a fixed percentage, prices also tend to fall by some fixed percentage. An example of the learning curve for integrated circuits from 1964 through 1975 is depicted in Figure 3-1. This figure indicates that for each doubling of cumulative unit output, the selling price in constant dollars has decreased by about 27 percent.

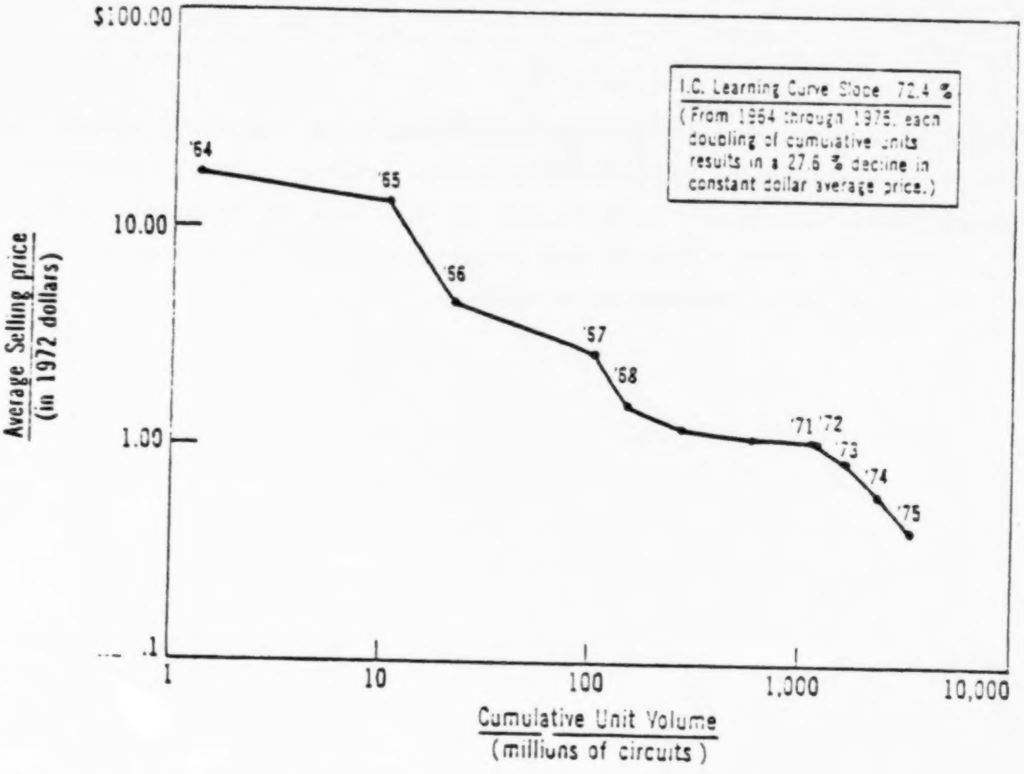
TABLE 3-6. PRICE INDEXES FOR SEMICONDUCTOR DEVICES
(1975 - 1980)

YEAR	INTEGRATED MICRO CIRCUITS (36741)[a]	TRANSISTORS (36742)[a]	DIODES AND RECTIFIERS (36743)[a]	OTHER SEMI-CONDUCTOR DEVICES (36749)[b]
1975	100.0	100.0	100.0	-
1976	93.3	97.8	102.3	100.0
1977	82.5	94.0	103.4	90.9
1978	69.3	91.7	101.6	85.8
1979	65.8	90.8	101.4	85.8
1980	71.1	98.2	102.2	86.1

[a] 1975 = base year

[b] 1976 = base year

SOURCE: Bureau of Labor Statistics, Producer Prices and Price Indexes (selected years).



Integrated Circuit Learning Curve Data

Year	Millions of I.C. Units		Annual Value ($millions)	Average Selling Price	
	Annual	Cumulative		Current Dollars	Constant '72 Dollars
1964	2	2	41	$18.50	$24.34
1965	10	12	79	8.33	11.21
1966	29	41	149	5.05	6.58
1967	69	110	228	3.32	4.20
1968	133	243	303	2.28	2.76
1969	253	496	413	1.63	1.88
1970	299	795	433	1.45	1.59
1971	362	1,156	443	1.23	1.28
1972	602	1,759	608	1.01	1.01
1973	1,060	2,819	1,049	0.99	0.94
1974	1,477	4,296	1,359	0.92	0.79
1975	1,375	5,671	1,100	0.80	0.63

Source: "Morgan Stanley Electronics Letter" October 15, 1976, Benjamin M. Rosen, Editor.

FIGURE 3-1. INTEGRATED CIRCUIT LEARNING CURVE

It should be noted that these factors may impede the industry's ability or inclination to pass through the costs of pollution control to their customers by raising prices. The extent to which some of the costs of pollution control could be passed through to customers may be observed in the form of slower declines in the prices of semiconductor products.

4. BASE CASE PROJECTIONS

This section provides projections of the growth and performance of the U.S. semiconductor industry over the regulatory impact analysis period in the absence of water pollution control requirements resulting from the Clean Water Act. The baseline projections in this report provide a general point of reference for the analysis and are not intended to be a comprehensive, authoritative forecast of future industry conditions. When the impact estimates (based on the estimated compliance costs) are compared against the baseline, the difference represents the estimated impact resulting from these regulations. The primary variables of interest are the projected sales, employment, and capital requirements.

4.1 U.S. SEMICONDUCTOR SALES PROJECTIONS

Growth in the U.S. and foreign markets for semiconductor products has been slow during the 1981-1982 period. The recession depressed the end-use markets causing shipments of semiconductor products to remain low over this period. In 1981 the value of shipments fell by about 4 percent from $9.4 billion to $9.1 billion. However, the industry shipments grew by about 5 percent in 1982 as lower prices stimulated the demand for semiconductor products.

The demand for semiconductor products is expected to increase rapidly as economic activity in the United States and rest of the world expands. According to the Department of Commerce, the value of shipments of semiconductor products will increase to $11.3 billion in 1983, or by 18.4 percent over the 1982 level.[6/] Between 1982 and 1987, industry shipments of semiconductor devices, are projected to grow at an annual rate of 16 percent. Shipments by 1987 are expected to reach $27 billion (Table 4-1).[7/]

[6/] U.S. Department of Commerce, U.S. Industrial Outlook 1983.

[7/] Ibid.

TABLE 4-1 U.S. SEMICONDUCTOR SHIPMENT FORECASTS ($ MILLIONS)

YEAR	VALUE OF SHIPMENTS
1979	7,356
1980	9,455
1981	9,076
1982[a]	9,539
1983[b]	11,294
1987[b]	27,000

[a] Estimated

[b] Forecast

SOURCE: U.S. Department of Commerce, U.S. Industrial Outlook 1983.

Growth in the semiconductor industry will be fueled by continued advances in both product and process technology. Many of the new devices, at the leading edge of technology only a few years ago, will find broad application by equipment producers. Devices such as microprocessors, high speed memories, and integrated power semiconductors, will be a part in a wide range of commercial and consumer electronic products.

4.2 CAPITAL EXPENDITURES PROJECTIONS

Capital investment requirements are generally high in the U.S. semiconductor industry compared to other industries. During the 1973-1977 historical period, the capital expenditures in this industry increased approximately eightfold from $52.4 to $409 million, and ranged from 6 percent to 12 percent of the industry's value of shipments. The high level of capital expenditures over this period is due mainly to rapid changes in both product and production technology which results in a high rate of equipment obsolescence. In order to maintain market share and growth semiconductor firms have had to invest continually in new equipment and technology. This trend is expected to continue over the regulatory impact period.

Capital expenditures are projected based on the average 1963-1977 historical capital expenditures/value of shipment ratio which equals .083. Using this historical relationship the estimate for new capital expenditures requirements would be $0.9 billion in 1983, and $2.2 billion, in 1987 (Table 4-2).

4.3 EMPLOYMENT PROJECTIONS

In the past, employment in the semiconductor industry has been increasing at a slower rate than the value of shipments. Table 4-3 shows that between 1972 and 1977, employment increased by 17 percent, while value of shipments nearly doubled. The lower employment growth rate was due to improved productivity which was a result of a combination of factors, including technological advancement and increasing transfer of assembly and other production activities

TABLE 4-2. NEW CAPITAL EXPENDITURES FOR THE SEMICONDUCTOR INDUSTRY, HISTORICAL[a] AND FORECAST[b] VALUES

YEAR	EXPENDITURES ($ MILLIONS)	PERCENT OF VALUE OF INDUSTRY SHIPMENTS
1963	52.4	7.6
1964	43.4	6.0
1965	61.3	6.7
1966	123.6	11.0
1967	131.1	11.5
1968	118.4	9.0
1969	143.6	9.1
1970	98.4	6.3
1971	94.3	5.9
1972	170.3	6.3
1973	334.6	9.2
1974	479.2	11.1
1975	282.9	8.6
1976	362.3	8.1
1977	409.0	8.3
1980	784.1	8.3
1983	931.4	8.3
1987	2,241.0	8.3

[a] Historical data on capital expenditures obtained from the U.S. Department of Commerce, Annual Survey of Manufactures.

[b] Projection based on the average historical capital expenditure to value of shipments relationship.

TABLE 4-3. SEMICONDUCTOR INDUSTRY EMPLOYMENT FORECASTS

YEAR	EMPLOYMENT (000)	VALUE OF SHIPMENTS ($ Millions)	VALUE OF SHIPMENTS/ EMPLOYMENT ($000/Employee)
1972	97.6	2,704.8	27.7
1973	120.0	3,647.7	30.4
1974	133.1	4,305.1	32.3
1975	96.7	3,276.9	33.9
1976	102.7	4,473.8	43.6
1977	114.0	5,322.6	46.7
1980^{P}	149.2	9,455	57.2$^{a/}$
1983^{P}	197.4	11,294	68.8$^{a/}$
1987^{P}	280.1	27,000	96.1$^{a/}$

P = Projected

$^{a/}$ Projected based on 1972-1977 historical trend

SOURCE: U.S. Department of Commerce, 1977 Census of Manufactures.

to U.S.-owned offshore facilities to take advantage of lower labor costs. It is expected that these productivity increases, measured in terms of value of shipment per employee, will continue as demonstrated in the past. The ratio of value of shipments to employees was projected over the regulatory impact period based on the historical trend of these variables. Using the forecasts of value of shipments (calculated above) and the time trend projections of the employee/value of shipment ratios, the level of employment in the semiconductor industry was calculated for this 1980-1987 period. These projections are also shown in Table 2-3. Total employment is projected to be 197,400 in 1983 and as high as 280,100 by 1987.

5. COST OF COMPLIANCE

5.1 OVERVIEW

The water treatment control systems, costs, and effluent limitations recommended for the semiconductor industry are enumerated in the Development Document for Effluent Limitation Guidelines and Standards of Performance for the Electrical and Electronic Components Point Source Category. That document identifies various characteristics of the industry including manufacturing processes, products manufactured, volume of output, raw waste characteristics, supply, volume and discharge destination of water used in the production processes, sources of waste and wastewaters, and the constituents of wastewaters. Using that data, pollutant parameters requiring effluent limitations or standards of performance were selected by EPA, and the costs of the treatment control systems to achieve certain standards of performance were estimated.

The EPA Development Document identifies and assesses the range of control and treatment technologies which apply to the semiconductor industry's effluent. This assessment involved an evaluation of both in-plant and end-of-pipe technologies that could be designed for this subcategory. This information was then evaluated for existing direct industrial dischargers to determine the effluent limitations achievable based on the "best practicable control technology currently available" (BPT), and the "best available technology economically achievable" (BAT). Similar evaluations were performed for new direct dischargers to develop new source performance standards (NSPS). Finally, pretreatment standards for existing sources (PSES) and pretreatment standards for new sources (PSNS) were developed for dischargers to publicly owned treatment works (POTW). Each of the technologies identified was analyzed to calculate cost and peformance. Cost data was expressed in terms of investment, operating and maintenance costs, depreciation, and interest expense. Pollution characteristics were expressed in terms of median and mean concentration levels (per liter of water).

5.2 POLLUTANT PARAMETERS

5.2.1 Pollution Parameters Analyzed

The selection of pollution parameters to be considered for regulation was based primarily on laboratory analyses of wastewaters sampled from several semiconductor plants and responses to a mail survey of semiconductor manufacturers. The specific approach to selecting the pollutant parameters is presented in Sections 5 and 6 of the Development Document. The chemical pollutants analyzed fall into three groups:

- Conventional
- Toxics
- Nonconventional.

Conventional pollutants are BOD, TSS, oil and grease, and pH. The toxic pollutants are comprised of 129 chemicals that are identified as priority pollutants. The nonconventional pollutants are those which are neither conventional nor are toxic pollutants.

5.2.2 Pollutants to be Regulated

The specific pollutants selected for regulation in the semiconductor subcategory are pH, fluoride, and total toxic organics (TTO). These pollutants are commonly generated during the manufacture of semiconductor products. See the Final Development Document for a description of the sources and levels of concentration of these pollutants in the wastewater.

5.3 RECOMMENDED TREATMENT TECHNOLOGIES

Based on the analysis of the potential pollution parameters and treatment-in-place in the semiconductor industry, EPA identified six treatment technologies that are most applicable for the reduction of the selected pollutants.

These treatment technologies are described in detail in Section 7 of the Development Document and are listed below.

- Option 1: Segregation and collection of spent solvents containing toxic organics for reuse, resale, or contract hauling (referred to as solvent management), plus end-of-pipe treatment for pH control.
- Option 2: Option 1 plus end-of-pipe precipitation/clarification for control of fluoride, arsenic, and suspended solids.
- Option 3: Option 1 plus precipitation/clarification of concentrated fluoride wastes for control of fluoride.
- Option 4: Option 2 plus recycle of treated effluent to further reduce pollutant discharges.
- Option 5: Option 2 plus filtration to further reduce pollutant discharges.
- Option 6: Option 5 plus activated carbon to further reduce toxic organics.

The Agency's evaluation of treatment options 4 and 6 concluded that these technologies would not be technically feasible for all semiconductor plants in the case of 4, and would remove little, if any, additional pollutants in the case of 6. For this reason, the economic impact analysis concentrated on treatment options 1, 2, 3, and 5 only.

5.4 TREATMENT COST ESTIMATES

Costs of compliance were estimated by EPA for treatment options 1, 2, 3, and 5. Treatment costs of option 1 are only for monitoring. Information available indicates that most semiconductor plants are practicing solvent management to some degree to control toxic organics, and that the incremental costs of disposal tend to be offset by resale (an estimated 53 percent of the facilities already meet the TTO limit). Moreover, all of these plants are controlling the pH of the discharges by end-of-pipe neutralization.

The monitoring costs for Option 1 are expected to apply to no more than approximately fifty percent of the plants in this subcategory because the regulation provides for a certification alternative to monitoring. EPA is unable to predict precisely which plants will incur monitoring costs; therefore, the economic impact was assessed for each plant. However, for purposes of estimating total compliance costs for this regulation, only half of these costs are included in the total since only half of the plants at most are expected to incur costs.

Appendix A-1 contains a sensitivity analysis on Option 1 costs and economic impacts.

In developing the compliance cost estimates for the treatment options, the following major assumptions were made by EPA:

- All costs are expressed in end-of-year 1979 dollars.
- The treatment facilities were assumed to operate 8 hours per day, 260 days per year for plants with discharge less than 60,000 gpd; 24 hours per day, 260 days per year for plants with 60,000 gpd to 200,000 gpd; and 24 hours per day, 350 days per year for plants with more than 200,000 gpd.
- Labor costs are based on an hourly rate of $20, including fringe benefits and plant overhead.
- The cost of land is valued at $12,000 per acre.
- Energy costs are based on $306 per horsepower.
- Sludge disosal costs are included. Available information indicates that the sludge generated from the treatment of fluoride is not defined as hazardous waste by RCRA.
- Capital costs are amortized at 5 years and 13 percent interest.
- The capital investment and total annual costs associated with quarterly monitoring the wastewater of a plant are $2,000 and $4,100, respectively.[8]

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[8] Total annual costs of monitoring include $3,500 annual operating and maintenance costs, and $600 annual capital costs.

5.4.1 Existing Sources

Based on the above assumptions, capital investment costs and annual compliance costs were estimated for treatment options 2, 3, and 5. The Final Development Document presents the cost curves for these three options. These cost curves were used to estimate the compliance costs for 21 semiconductor plants. Key operating characteristics for the 21 plants are presented in Table 5-1, and the average investment and annual costs for pollution control are presented in Table 5-2. The five model plant size groupings were based on the plant sizes defined in Table 3-2 as well as wastewater flow rates and other data developed from a technical EPA survey of the industry.

Using the average costs for the various pollution control options by employee size classification in Table 5-2, the compliance costs for the total industry were calculated and are shown in Table 5-3.[9]

5.4.2 New Sources

The basis for the new source standards (NSPS and PSNS) is the best available demonstrated technology (BDT), including in-plant controls and end-of-pipe treatment technologies that provide the maximum pollution reductions feasible. For the semiconductor subcategory, the proposed NSPS and PSNS discharge limitations are the same as those proposed for BAT and PSES. Since new source costs are defined as incremental costs from BAT and PSES, costs of NSPS and PSNS are zero.

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[9] The average investment and annual compliance costs were multiplied by the total number of plants in each size classification to determine the total compliance cost by size classifications. The results were then summed to determine the total industry compliance costs. Note that the number of direct plants incurring costs for Option 3 is different because of treatment-in-place.

TABLE 5-1. SEMICONDUCTOR PLANT OPERATING STATISTICS

PLANT ID #	NUMBER OF PRODUCTION EMPLOYEES	TOTAL FLOW RATE (GPD) (000's)	FLOW RATE FOR CONCENTRATED FLUORIDE ACID WASTE (GPD)
A	4,650	2,494	6,290
B	2,395	540	1,340
C	40	43	120
D	353	360	912
E	600	290	700
F	3,600	2,013	5,090
G	2,100	408	1,030
H	733	280	696
I	1,800	432	1,080
J	2,500	3,026	7,560
K	800	663	1,660
L	60	50	120
M	300	324	65
N	150	2	24
O	50	3	4
P	300	14	24
Q	1,150	199	504
R	33	151	384
S	12,450	792	1,990
T	60	35	720
U	595	41	98

SOURCE: The EPA Effluent Guidelines Division.

TABLE 5-2. MODEL PLANT COMPLIANCE COSTS
(thousands of 1979 dollars)

			AVERAGE COMPLIANCE COST PER PLANT ($000)							
			OPTION 1[a]		OPTION 2		OPTION 3		OPTION 5	
SIZE OF PLANTS	NUMBER OF SAMPLE PLANTS	AVERAGE FLOW RATE (GPD)	CAPITAL INVESTMENT	ANNUAL COSTS	CAPITAL INVESTMENT	ANNUAL COSTS	CAPITAL INVESTMENT	ANNUAL COSTS	CAPITAL INVESTMENT	ANNUAL COSTS
Small (1-99 Employees)	5	56,772	2.0	4.1	245	180	63.5	38	280.2	197
Medium-Small (100-499 Employees)	4	174,450	2.0	4.1	405.1	305	68.05	49	458.7	333
Medium-Large (500-999 Employees)	4	318,325	2.0	4.1	504.4	396	75.61	59	583.8	427
Large (Over 1,000 Employees)	8	1,238,224	2.0	4.1	891.6	698	116.64	94	1,002	764

[a] The costs associated with Option 1 include only monitoring costs. The costs associated with solvent disposal are negligible.

SOURCE: Compiled by JRB Associates.

TABLE 5-3. TOTAL INDUSTRY COMPLIANCE COSTS
(thousands of 1979 dollars)

SIZE OF PLANTS	ESTIMATED NUMBER OF PLANTS	TOTAL COMPLIANCE COST							
		OPTION 1*		OPTION 2		OPTION 3**		OPTION 5	
		CAPITAL INVESTMENT	ANNUAL COSTS	CAPITAL INVESTMENT	ANNUAL COSTS	CAPITAL INVESTMENT	ANNUAL COSTS	CAPITAL INVESTMENT	ANNUAL COSTS
Small (1-99 Employees)	Direct 41	41	84	10,041	7,295	1,674[a]	1,000[a]	11,447	7,991
	Indirect 95	95	195	23,270	16,904	5,938	3,417	26,522	18,516
	Subtotal 136	136	279	33,313	24,199	7,612	4,417	37,969	26,507
Medium-Small (100-499 Employees)	Direct 25	25	51	10,104	7,585	1,131[a]	809[a]	11,444	8,285
	Indirect 58	58	119	23,441	17,597	3,889	2,703	26,549	19,218
	Subtotal 83	83	170	33,545	25,182	5,020	3,512	37,993	27,503
Medium-Large (500-999 Employees)	Direct 5	5	10	2,575	1,971	222[a]	119[a]	2,914	2,124
	Indirect 13	13	27	6,700	5,121	970	752	7,577	5,519
	Subtotal 18	18	37	9,275	7,092	1,192	931	10,491	7,643
Large (Over 1,000 Employees)	Direct 6	6	12	5,344	4,177	577[a]	465[a]	6,006	4,570
	Indirect 14	14	29	12,468	9,745	1,619	1,294	14,014	10,662
	Subtotal 20	20	41	17,812	13,922	2,196	1,759	20,020	15,232
TOTAL	Direct 77	77	158	28,078	21,126	3,604[a]	2,452[a]	31,811	22,968
	Indirect 180	180	369	65,870	49,368	12,147	8,167	74,662	53,916
	Total 257	257	527	93,947	70,394	15,751	10,619	106,473	76,884

[a] Incremental costs for Option 3 from Option 1 apply to the following numbers of plants: small 27, medium-small 17, medium-large 3, large 5 = 52. See text for explanation of why this distribution is different.

* Selected Option for Indirect Dischargers Costs are computed assuming that 50% of all plants will monitor; the remaining plants are assumed to certify under the provisions in the regulation.

** Selected Option for Direct Dischargers.

SOURCE: Compiled by JRB Associates from data provided by the Effluent Guidelines Division.

6. ECONOMIC IMPACTS

This chapter provides an assessment of the economic impacts that are likely to occur as a result of the costs of the effluent control/treatment technologies described in Chapter 3. The analysis is based upon the examination of the estimated compliance costs, other economic and financial characteristics of 21 sample plants, and the analytical methodology described in Chapter 2. The primary economic impact areas discussed include the effect of the pollution control costs on semiconductor prices, the profitability of semiconductor manufacturing, plant closures, employment, changes in imports and exports, and industry structure. The analysis is not intended to be plant-specific; instead, the sample plants serve only as a basis for deriving indications of potential industry-wide impacts.

6.1 PRICE AND QUANTITY IMPACTS

The price and quantity impacts of the compliance costs are determined through an examination of industry market structure and pricing behavior. Economic theory predicts different pricing behavior for different market structures (e.g., competitive, oligopoly, monopoly). As described in Chapters 2 and 3, the market structure for this industry is not precisely determined in this study. Nevertheless, there is evidence that the semiconductor industry has both the incentive and the capability to completely absorb all small and moderate levels of mandated pollution control costs. The incentive not to raise product prices is in the form of significant international competition for world market share; and the capability is implied by the variations in profit rates among various semiconductor products within multi-product firms. For these reasons it is assumed that there will be no price changes resulting from the regulation in the short and intermediate time period.

6.2 PLANT LEVEL PROFIT IMPACT ANALYSIS

The basic profitability measure used in this study is before-tax return on sales, or profit margin (PM). The profitability of a plant is considered to be significantly impacted if the total annual compliance costs reduce the return on sales of a plant to an extent that it is equal to or less than the lowest average industry PM. As described in Chapter 2, The lowest acceptable PM was determined to be 2.7 percent. This is based on the performance of the semiconductor industry over the 1971-1977 period.[10]

Table 6-1 presents data on the actual number of production employees and the estimated value of shipments for each sample plant. The value of shipments data, along with the total annual compliance cost estimates for each of the recommended treatment options for the semiconductor plants, are used to analyze the performance of the plants after compliance.

Table 6-2 presents the percent of annual revenues that is estimated to be spent annually to operate, maintain, and finance the proposed pollution control technologies for each of the options considered for the sample plants. This table was developed from the value of shipments data in Table 6-1 and the compliance cost data from EPA. Compliance costs for option 1 (Selected Option for PSES) are estimated to be negligible for the reasons discussed previously. (A sensitivity analysis for option 1 appears in Appendix II-A.) Option 3 (Selected Option for BAT) costs are considered relatively insignificant; there are only three plants that have treatment costs greater than 1 percent of the estimated annual revenues of the plant. The post-compliance profit margins for these plants are not below the threshold value for profitability. The annual compliance costs associated with options 2 and 5 are much more significant. Eight of the plants examined may incur costs that range from 1-12 percent of their annual revenues. Four of the eight sample plants have PMs below the threshold value, all of which are small plants.

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[10] U.S. Department of Commerce, U.S. Semiconductor Industry, September 1979.

TABLE 6-1. SALIENT STATISTICS FOR THE SEMICONDUCTOR SAMPLE PLANTS

PLANT ID CODE	PRODUCTION[a] EMPLOYEES	VALUE OF[b] SHIPMENTS	NEW CAPITAL[b] EXPENDITURES
A	4,650	389,765,186	29,950,393.70
B	2,395	200,750,026	15,426,062.99
C	40	3,352,819	257,637.80
D	353	29,588,626	2,273,653.54
E	600	50,292,282	3,864,566.93
F	3,600	301,753,692	23,187,401.57
G	2,100	176,022,987	13,525,984.25
H	733	61,440,405	4,721,212.60
I	1,800	150,876,846	11,593,700.79
J	2,500	209,551,175	16,102,362.20
K	800	67,056,376	5,152,755.91
L	60	5,029,228	386,456.69
M	300	25,146,141	1,932,283.46
N	150	12,573,071	966,141.73
O	50	4,191,024	322,047.24
P	300	25,146,141	1,932,283.46
Q	1,150	96,393,541	7,407,086.61
R	33	2,766,076	212,551.18
S	12,450	1,043,564,852	80,189,763.78
T	60	5,029,228	386,456.69
U	595	49,873,180	3,832,362.20

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[a] SOURCE: EPA, Effluent Guidelines Division

[b] Estimates derived from average industry ratios obtained from the Bureau of Census, Census of Manufactures, 1977.

TABLE 6-2. SEMICONDUCTORS - ANNUAL COMPLIANCE COSTS[a/] AS A PERCENTAGE OF REVENUES

PLANT ID CODE	TREATMENT OPTION 1	TREATMENT OPTION 2	TREATMENT OPTION 3	TREATMENT OPTION 5
A	.00	.27	.03	.29
B	.00	.27	.04	.34
C	.12	5.35	1.02	5.65
D	.01	1.51	.23	1.65
E	.01	.81	.12	.88
F	.00	.31	.04	.34
G	.00	.27	.04	.29
H	.01	.65	.10	.71
I	.00	.32	.05	.35
J	.00	.54	.07	.58
K	.01	.90	.12	.94
L	.08	3.81	.68	4.21
M	.02	1.70	.24	1.85
N	.03	.39	.27	.44
O	.10	1.40	.81	1.58
P	.02	1.18	.13	1.30
Q	.00	.36	.06	.39
R	.15	11.10	1.81	12.17
S	.00	.06	.01	.07
T	.08	3.24	.08[b/]	3.59
U	.01	.35	.07	.39

[a/] The annual compliance costs for each of the treatment options include monitoring costs. These costs are estimated at $4,100 per plant annually.

[b/] Information on concentrated fluoride acid waste was not available for this plant.

6.3 CAPITAL REQUIREMENTS ANALYSIS

As described in Chapter 2, the assessment of the firm's ability to raise the required capital is based on ratios of compliance capital investment to average annual compliance expenditures. Because of the absence of plant-specific financial data, the annual capital expenditures of the plants are calculated from the industry average new capital expenditures per production employee ratios reported in the 1977 Census of Manufactures. The estimated annual capital expenditures from Table 6-1, along with capital investment costs for each of the pollution control options, are used to indicate the significance of the capital impacts.

Table 6-3 presents the compliance capital investment to plant capital investment ratios for the 21 sample plants. These ratios reveal that the proposed pollution control costs would range from zero to 30 percent of the average annual capital expenditures for options 1 and 3. Investment costs of these magnitudes are not by themselves enough to cause plant closures. The pollution control investment costs are more significant for options 2 and 5. Four of the plants, all of which are small, would have to invest more than 50 percent of their annual capital expenditures in pollution control to comply with the proposed regulation. These results will be used below, together with other information, to assess the potential for plant closure.

6.4 POTENTIAL PLANT CLOSURES

As described in Chapter 2, potential plant closures are estimated by simultaneously examining the results of the profit and capital impact assessments for the sample plants, and qualitatively assessing other nonquantified factors. Using these results, possible closures are identified, and then used as the basis for extrapolating industry closures.

It is assumed that a plant would close if the costs of pollution control caused its profit margin to fall below 2.7 percent, and/or if a plant had to

TABLE 6-3. SEMICONDUCTORS - POLLUTION CONTROL INVESTMENT COSTS AS A PERCENT OF ANNUAL CAPITAL EXPENDITURES a/

PLANT ID CODE	TREATMENT OPTION 1	TREATMENT OPTION 2	TREATMENT OPTION 3	TREATMENT OPTION 5
A	.01	4.35	.57	4.88
B	.01	4.51	.59	5.08
C	.78	95.75	24.65	109.20
D	.09	25.87	3.41	29.24
E	.05	13.92	1.82	15.74
F	.01	5.15	.67	5.77
G	.01	4.58	.60	5.17
H	.04	11.24	1.47	12.71
I	.02	5.47	.72	6.17
J	.01	8.77	1.14	9.81
K	.04	14.67	1.92	16.53
L	.52	67.99	16.43	77.49
M	.10	29.15	3.50	32.95
N	.21	7.23	6.57	8.34
O	.62	25.94	19.72	29.89
P	.10	20.66	3.29	23.44
Q	.03	6.22	.86	7.05
R	.94	193.65	29.88	219.66
S	.00	1.01	.13	1.14
T	.52	58.26	.52 b/	66.50
U	.05	6.29	1.66	7.17

a/ Monitoring costs are included in the pollution control investment costs for each of the treatment options.

b/ Information on the concentrate fluoride acid wastes was not available for this plant.

spend more than 100 percent of its annual capital expenditures on pollution control equipment.

The pollution control costs associated with the selected options 1 and 3 are not great enough to cause plant closures. However, the analysis of the pollution control costs associated with treatment options 2 and 5 indicate that the annual profit margins for four of the plants examined may be reduced below 2.7 percent, and that these four plants will have to invest significant portions of an average year's capital expenditures in pollution control equipment. Under these circumstances, four, or 19%, of the sample plants are identified as likely candidates for closure, if they were required to install treatment option 2 or 5. All four plants are small, with employment ranging from 33 to 60 employees. The results of the sample plant analysis are used as the basis for estimating plant closures at the industry level. These estimates are shown in Table 6-4. It is assumed that the percentage of industry plant closures will be the same as that indicated for the sample plants. Using this approach, it is estimated that 19 percent or 48 of the plants in the semiconductor industry are likely to close under options 2 or 5. Of these 48 plants, it is estimated that 14 are likely to be direct and 34 indirect dischargers. The number of direct versus indirect dischargers that are likely to close is estimated using the pre-compliance ratio of direct to indirect dischargers for the total industry.11/

6.5 EMPLOYMENT IMPACTS

In general, a regulation can impact on employment in an industry through job losses that are associated with closures, and from price increases that

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11/ An important qualification to these extrapolations is in order. First, 136, or 53 percent, of the 257 plants in the industry are small (employ fewer than 100 production employees). However, only 5, or 24 percent, of the plants in the EPA sample were small plants, indicating that the economic impact estimates based on these data may not fully represent the range of likely impacts among small plants. For example, if 80 percent of small plants closed (4 out of 5 small plants in the sample), then the costs of options 2 or 5 could result in (0.8)(136) = 109 plant closures, instead of the 48 estimated above.

TABLE 6-4. POTENTIAL PLANT CLOSURES AND EMPLOYMENT IMPACTS FOR SEMICONDUCTOR PLANTS

SIZE OF PLANTS	ESTIMATED # OF PLANTS BY DISCHARGE STATUS	OPTION 1		OPTION 2		OPTION 3		OPTION 5	
		POTENTIAL PLANT CLOSURES	CHANGE IN EMPLOYMENT	POTENTIAL PLANT CLOSURES	CHANGE IN EMPLOYMENT	POTENTIAL PLANT CLOSURES	CHANGE IN EMPLOYMENT	POTENTIAL PLANT CLOSURES	CHANGE IN EMPLOYMENT
Small	Direct	0	0	14	686	0	0	14	686
	Indirect	0	0	34	1,666	0	0	34	1,666
	Subtotal	0	0	48	2,352	0	0	48	2,352
Medium-Small	Direct	0	0	0	0	0	0	0	0
	Indirect	0	0	0	0	0	0	0	0
	Subtotal	0	0	0	0	0	0	0	0
Medium-Large	Direct	0	0	0	0	0	0	0	0
	Indirect	0	0	0	0	0	0	0	0
	Subtotal	0	0	0	0	0	0	0	0
Large	Direct	0	0	0	0	0	0	0	0
	Indirect	0	0	0	0	0	0	0	0
	Subtotal	0	0	0	0	0	0	0	0
Total	Direct	0	0	14	686	0	0	14	686
	Indirect	0	0	34	1,666	0	0	34	1,666
	Total	0	0	48	2,352	0	0	48	2,352

SOURCE: Compiled by JRB Associates.

cause output and employment to fall. Since no plant closures or price changes are expected for either options 1 or 3 the regulation is not expected to have any impact on the level of unemployment for these options. On the other hand, 48 plants are likely to close if either treatment option 2 or 5 technologies are required. Since all of the potential closures are small plants (i.e., having between 1 and 99 employees), and the average number of employees in the small plants is 49, it is estimated that 2,352 employees (i.e., 48 plants multiplied by 49 employees) may lose their jobs if either of these two pollution control technologies is required.

6.6 FOREIGN TRADE IMPACTS

The impact of the regulation on the levels of imports and exports depends on (1) the extent that semiconductor product prices in the domestic market rise faster than prices in the rest-of-world market, and (2) the extent to which the domestic production losses are replaced by imports from foreign countries. Because the domestic producers are not expected to increase the price of semiconductor products as a result of this regulation they should continue to be competitive with foreign producers. Therefore, there will be no foreign trade impact from this factor. The increase in imports of semiconductor products because of domestic capacity reductions (i.e., plant closures) is difficult to quantify precisely. For this analysis, it is assumed that the production losses will be made up by U.S. producers only. Therefore, no balance of payment impacts are predicted.

6.7 NEW SOURCE IMPACTS

As indicated in Chapter 5, the incremental costs of NSPS and PSNS are zero. Because there is no difference in compliance costs between similar existing and new sources, the regulation would not foster any competitive advantages or disadvantages between new and existing sources.

6.8 SUMMARY OF SEMICONDUCTOR INDUSTRY ECONOMIC IMPACTS

The estimated economic impacts for the selected options in the semiconductors subcategory are summarized in Table 6-5.

Toxic Organics

The control of toxic organics and pH under Option 1 for BPT and PSES is expected to cause compliance costs for monitoring of $257 thousand in capital investment and $527 thousand annually. These costs are based on two assumptions, as with the crystals subcategory. First, at least the 50% of the facilities currently in compliance with toxic organic limitation are expected to choose to certify that they do not dump solvents into their effluent instead of monitoring. Second, these remaining plants that do monitor will, on average, be required to do so quarterly. Since the incremental costs of solvent disposal tend to be offset by resale, EPA did not estimate costs for solvent management. Monitoring costs are less than 0.2% of annual revenues and are not expected to cause other than minor profitability impacts. No plant closures are expected.

In addition to the above analysis, EPA conducted a sensitivity analysis (reported in Appendix II-A) for Option 1 costs consisting of two parts. First, the impact of monthly monitoring was estimated for all facilities (some facilities may be required to monitor as frequently as once per month, although EPA cannot identify precisely which ones). In addition to this analysis, costs and impacts were also determined for facilities which may incur "worst case" solvent disposal costs. These costs are developed for facilities that could fall under the requirements of the Resource Conservation and Recovery Act (RCRA) for disposal.

The analysis of these costs shows that while the effects of these costs are somewhat higher, they still represent less than 2.3% of annual revenues. These would be expected to cause some profit reductions, but not enough to cause any plant closures.

TABLE 6-5. SUMMARY OF ESTIMATED ECONOMIC IMPACTS
FOR THE SEMICONDUCTORS SUBCATEGORY

ECONOMIC IMPACT VARIABLES	OPTION 1*	OPTION 2	OPTION 3**	OPTION 5	SELECTED OPTION
Annual Compliance Costs/Revenues (%)					
Indirect Dischargers	0-0.2	0.1-11.1	0.01-2.0	0.1-12.2	0-0.2
Direct Dischargers	0-0.2	0.1-11.1	0.01-2.0	0.1-12.2	0.01-2.0
Change in Price (%)	0	0	0	0	0
Change in Quantity (%)	0	0	0	0	0
Change in Profitability					
Indirect Dischargers	Low	Signif.	Low	Signif.	Low
Direct Dischargers	Low	Signif.	Low	Signif.	Low
Capital Requirements					
Indirect Dischargers	Low	Signif.	Low	Signif.	Low
Direct Dischargers	Low	Signif.	Low	Signif.	Low
Plant Closures due to Regulations					
Indirect Dischargers	0	34	0	34	0
Direct Dischargers	0	14	0	14	0
Employment at Closed Plants					
Indirect Dischargers	0	1,666	0	1,666	0
Direct Dischargers	0	686	0	686	0
Balance of Trade Changes	None	None	None	None	None
Industry Structure Changes	None	Signif.	None	Signif.	None

* Selected Option for Indirect Dischargers

** Selected Option for Direct Dischargers

Fluoride

EPA's limits on fluoride under Option 3 for BAT will require an estimated 52 of 77 facilities to spend $3.6 million in capital investment and $2.9 million annually (including monitoring) to comply with the regulations. These costs are not expected to cause other than small reductions in profitability. No plant closures are expected.

New Sources

The effluent standards and associated technologies for new sources are identical to those for existing sources. Consequently, the economic impacts for new sources will mirror those of existing sources and the promulgated regulations are not expected to foster competitive advantages of disadvantages between new and existing sources.

6.9 LONG-TERM IMPLICATIONS AND OTHER IMPACTS

In spite of the impressive growth of the semiconductor industry, a prosperous future is not guaranteed. Technological obsolescence and foreign competition are likely to continue to be of great concern to the industry. Because of this, capital expenditures for R&D and new equipment are very high. Failure to keep pace on a year-to-year basis may mean the loss of important market segments to competitors, which in many cases are European or Japanese companies. The costs associated with EPA regulations could add to these problems if the added burden were significant. It may force some firms into a noncompetitive position and could lead to potential plant closures in the long run, or it could lead to a firm's relocating their wafer fabrication operations overseas. Most companies already have moved their labor intensive assembly operations overseas, and it would be quite possible for them to relocate wafer fabrication as well. Such a move would result in a loss of employment, wages, and a substantial adverse shift in the current balance of trade.

6.10 SMALL BUSINESS ANALYSIS

The Regulatory Flexibility Act (RFA) of 1980 (P.L. 96-354) requires Federal regulatory agencies to consider "small entities" throughout the regulatory process. The RFA requires analyses to be performed which determine if a substantial number of small entities will be significantly impacted. If so, regulatory alternatives that eliminate or mitigate the impact must be considered. This analysis addresses these objectives by identifying and evaluating the degree of economic impacts of the aforementioned regulations on small entities (the primary small entity affected by these regulations is the small semiconductor manufacturer). As described in Chapter 2 the small business analysis was developed as an integral part of the general economic impact analysis described above in this report.

6.10.1 Definitions of Small Business

As described in Chapter 2, the definition of small for purposes of regulatory analysis is not precise or universal. The small business defintions used by other Federal agencies, which were developed for purposes other than regulatory analysis was found to be inappropriate for this study. Instead, information on both the amount of effluent discharged and the number of employees working in the plants was used to determine an appropriate cutoff point that identifies small entities. The criterion selected consider plants with fewer than 100 employees as small entities because at this cutoff point the plants within this subcategory have some special and distinct properties. Table 6-6 illustrates the pollution discharge characteristics of plants in the industry by employment size categories. The information presented demonstrates that the small plants (i.e., plants with less than 100 employees) discharge an average of 57 thousand gallons of wastewater per day. Furthermore, although the small plants make up more than 50 percent of the plants in the industry they discharge only 15 percent of the wastewater.

TABLE 6-6. SEMICONDUCTOR - AVERAGE PLANT AND TOTAL INDUSTRY FLOW RATES

Size of Plant	DISCHARGE STATUS		TOTAL # OF PLANTS	AVERAGE FLOW RATE (GPD)	Total Flow Rates (GPD)	
	DIRECT	INDIRECT			Total	%
Small (1-99 Employees)	41	95	136	56,772	7,720,992	15
Medium-Small (100-499 Employees)	25	58	83	174,450	14,479,350	27
Medium-Large (500-999 Employees)	5	13	18	318,325	5,729,850	11
Large (Over 1,000 employees)	6	14	20	1,238,224	24,764,480	47
Total	77	180	257	205,038	52,694,672	100

SOURCE: Compiled by JRB Associates.

6.10.2 Impacts on Small Entities

Table 6-7 shows the average ratios of compliance costs to revenues and the pollution control investment costs to annual new capital expenditures which are associated with plants of various sizes in the semiconductor industry. The information in this table indicates that the smaller plants (i.e., the plants with less than 100 employees) would be more severely affected than the larger plants. In fact, the impact variables examined are at least 3 times greater for the small plants than for larger plants. In addition, all the projected plant closures are small plants if either treatment option 2 or 5 are required.

However, under Option 1 (selected option for PSES) and Option 3 (selected option for BAT) the absolute of the economic impacts is not considered large, with only 3 plants passing the screening threshold level for profitability, and none of which show significant profitability impacts upon closer examination. Therefore, the selected options for promulgation are not expected to have a significant impact on small facilities in this industry.

TABLE 6-7. SUMMARY PROFIT AND CAPITAL IMPACT ANALYSES BY EMPLOYEE SIZE CLASSIFICATION
(Percent)

SIZE CLASSIFICATION	AVERAGE ANNUAL COST TO REVENUES (%)				AVERAGE INVESTMENT COST TO ANNUAL CAPITAL EXPENDITURES (%)			
	OPTION 1	OPTION 2	OPTION 3	OPTION 5	OPTION 1	OPTION 2	OPTION 3	OPTION 5
Small (1-99 employees)	.09	4.98	.88	5.44	.68	88.32	18.24	100.55
Medium-Small (100-499)	.02	1.19	.21	1.31	.12	20.7	4.19	23.49
Medium-Large (500-999)	.01	.68	.10	.73	.04	11.53	1.72	13.04
Large 1,000 >	.003	.30	.04	.33	.01	5.0	.66	5.63

SOURCE: Compiled by JRB Associates

7. LIMITATIONS OF THE ANALYSIS

This section discusses the major limitations of the economic impact analysis. It focuses on the limitations of the data, methodology, assumptions, and estimations made in this report. Information pertaining to the estimation of the compliance costs for specific plants and the limitations of the method are outlined in Section 9 of the EPA Development Document.

The economic impacts assessed are the result of this regulation. The assessment does not include the economic impacts from other regulations for air pollution control, OSHA requirements, and solid waste requirements.

7.1 DATA LIMITATIONS

The major assumptions and estimates that have the greatest impact on the accuracy of the conclusions of this report relate to the data used in the analysis. It is important to realize that (1) no economic survey was conducted to collect plant-specific financial and economic data, and (2) these types of data are not in the public domain for this industry. As a result, most of the plant-specific data used are estimates derived from average industry operating and financial ratios. The plant-specific financial data must, therefore, be considered order-of-magnitude estimates, and not the actual data for specific plants.

The value of shipments and new capital expenditures were estimated by multiplying the number of production employees at each plant by the appropriate average industry performance ratio obtained from the Census of Manufactures. This methodology relies on the assumptions that a fixed relationship exists between the key performance variables for all plants, and that this relationship remains constant over time. These assumptions are probably invalid in the real world because of the following factors:

- Worker productivity varies significantly among plants
- The type, scale, and age of technologies vary widely among plants and greatly affect the value added by each production employee
- The type of products produced greatly affects the value added per employee or unit of raw material used; and product mix varies from one plant to another.

Ignoring these factors could result in overestimating the impacts on some plants while underestimating those of other plants. The reason for these potential errors is that the intra-industry variation in baseline conditions is underestimated. That is, baseline conditions for lower-profit plants are probably overstated and those of high-profit plants understated.

7.2 METHODOLOGY

7.2.1 Price Increases

The analysis assumes that the semiconductor industry will not increase the price of their products and pass through any portion of the compliance costs to their customers. While this is a reasonable assumption for some semiconductor products it may not be true for all the product segments in the semiconductor industry. It is possible that the price pass-through percentage will vary among the various semiconductor products. Adequate information on these segments is not available. Therefore, no further analysis is carried out to measure the extent of a price increase which may occur as the production costs of the plants increase with the installation of pollution control.

The estimation error which might result from the price change assumptions depends primarily on the cross elasticity of demand with respect to the ratio of domestic to foreign prices. That is, if increased domestic prices shift demand production overseas, there would be a drop in aggregate quantities produced by domestic producers and, consequently, increased unemployment and possibly other impacts. Thus, the remaining domestic semiconductor producers would have healthy profits, but account for a smaller portion of world market share. On the other hand, if such shifts were small, then domestic producers could raise prices to cover compliance expenditures without losing market share.

If the latter situation prevailed in the real world, the economic impacts estimated in this report are overstated. If the former situation prevailed, the impacts would take a different form, but would probably not exceed the levels estimated in Chapter 6 of this report.

7.2.2 Sensitivity Analysis

In addition to the biases that may be generated by the method used to estimate revenues and new capital expenditures of individual plants, the results of the analysis can be influenced by the pollution control cost data. To evaluate some of the problems associated with these data, sensitivity analyses were performed. For this analysis, the estimated compliance costs were varied by -20 percent and +20 percent. Tables 7-1 and 7-2 present the results of the sensitivity analysis on the profitability and capital availability assessments for all the recommended treatment options. The tables show that the changes in the pollution control costs (or equivalently, changes in revenue and capital expenditure estimates) would not significantly change the post-compliance financial ratios and the study's results for treatment options 1 and 3. For treatment options 2 and 5, reductions in the pollution control costs by 20 percent would not cause changes to the previous results. Alternatively, increases in the pollution control costs by 20 percent may cause 2 additional plants to close (i.e., six of the sample plants instead of four plants, as predicted in the impact analysis in Chapter 6, are likely to close). Therefore, incorrect costs for these options (options 2 and 5) could significantly affect the findings of the study. On the other hand, incorrect costs for options 1 and 3 are not likely to alter the findings of the study.

TABLE 7-1. SEMICONDUCTORS SENSITIVITY ANALYSIS - ANNUAL COMPLIANCE COSTS AS A PERCENTAGE OF REVENUES

PLANT CODE	OPTION 1		OPTION 2		OPTION 3		OPTION 4	
	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%
A	0	0	.216	.324	.024	.036	.232	.348
B	0	0	.216	.324	.032	.048	.272	.408
C	.096	.144	4.28	6.42	.816	1.224	4.52	6.78
D	.008	.012	1.208	1.812	.184	.276	1.32	1.98
E	.008	.012	.648	.972	.096	.144	.704	1.056
F	0	0	.248	.372	.032	.048	.272	.408
G	0	0	.216	.324	.032	.048	.232	.348
H	.008	.012	.52	.78	.08	.12	.568	.852
I	0	0	.256	.384	.04	.06	.28	.42
J	0	0	.432	.648	.056	.084	.464	.696
K	.008	.012	.72	1.08	.096	.144	.752	1.128
L	.064	.096	5.448	8.172	.544	.816	3.368	5.052
M	.016	.024	1.36	2.04	.192	.288	1.48	2.22
N	.024	.036	.312	.468	.216	.324	.352	.528
O	.08	.12	1.12	1.68	.648	.972	1.264	1.896
P	.016	.024	.944	1.416	.104	.156	1.04	1.56
Q	0	0	.288	.432	.048	.072	.312	.468
R	.12	.18	8.88	13.32	1.448	2.172	9.736	14.604
S	0	0	.048	.072	.008	.012	.056	.084
T	.064	.096	2.592	3.888	.064	.096	2.872	4.308
U	.008	.012	.28	.42	.056	.084	.312	.468

SOURCE: Compiled by JRB Associates

TABLE 7-2. SEMICONDUCTORS SENSITIVITY ANALYSIS - POLLUTION CONTROL INVESTMENT COSTS AS A PERCENTAGE OF NEW CAPITAL EXPENDITURES

PLANT	OPTION 1		OPTION 2		OPTION 3		OPTION 5	
CODE	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%
A	.008	.012	3.48	5.22	.456	.684	3.904	5.856
B	.008	.012	3.608	5.412	.472	.708	4.064	6.096
C	.624	.936	76.6	114.9	19.72	29.58	87.36	131.04
D	.072	.108	20.696	31.044	2.728	4.092	23.392	35.088
E	.04	.06	11.136	16.704	1.456	2.184	12.592	18.888
F	.008	.012	4.12	6.18	.536	.804	4.616	6.924
G	.008	.012	3.664	5.496	.48	.72	4.136	6.204
H	.032	.048	8.992	13.488	1.176	1.764	10.168	15.252
I	.016	.024	4.376	6.564	.576	.864	4.936	7.404
J	.008	.012	7.016	10.524	.912	1.368	7.848	11.772
K	.032	.048	11.736	17.604	1.536	2.304	13.224	19.836
L	.416	.624	54.392	81.588	13.144	19.716	61.992	92.988
M	.08	.12	23.32	34.98	2.8	4.2	26.36	39.54
N	.168	.252	5.784	8.676	5.256	7.884	6.672	10.008
O	.496	.744	20.752	31.128	15.776	23.664	23.912	35.868
P	.08	.12	16.528	24.792	2.632	3.948	18.752	28.128
Q	.024	.036	4.976	7.464	.688	1.032	5.64	8.46
R	.752	1.128	154.92	232.38	23.904	35.856	175.728	263.592
S	0	0	.808	1.212	.104	.156	.912	1.368
T	.416	.624	46.608	69.912	.416	.624	53.2	79.8
U	.04	.06	5.032	7.548	1.328	1.992	5.736	8.604

SOURCE: Compiled by JRB Associates

7.3 PLANT CLOSURES

The criteria for plant closure is not all-inclusive. It does not address the long-term financial condition of the plants, captive operations, the time value of money, the amount of invested capital, or other factors which affect closure decisions. A more detailed closure analysis would require more precise data on the long-term capital structure, cash flow, and the profitability of plants in the semiconductor industry. However, the costs of the recommended treatment technology are small, and a more detailed analysis will not necessarily yield different results.

7.4 SAMPLING

The statistical significance of the 21-plant sample is skewed in such a way that the large plants are adequately covered. However, most of the plants in the semiconductor industry are small, and these plants are represented by only a few plants in the sample.

7.5 SUMMARY OF LIMITATIONS

Although a number of assumptions and data limitations may significantly bias the economic impact conclusions, the potential changes to the conclusions resulting from the elimination of these biases are probably small. Consequently, the above methodology appears to have provided a reasonable industry-wide assessment of potential impacts.

APPENDIX II-A

SENSITIVITY ANALYSIS ON OPTION I COSTS

I. INTRODUCTION

The costs used to analyze the economic impact of option 1 in the semiconductors subcategory analysis are based on two assumptions: (1) that the only costs associated with compliance consist of monitoring costs, and (2) that monitoring will occur, on average, once per quarter for the affected plants. This analysis consists of two parts. The first part estimates the economic impact of monthly monitoring on individual plants in place of the quarterly monitoring. The second part estimates the economic impacts of "worst case" incremental solvent disposal costs.

II. MONITORING COST SENSITIVITY ANALYSIS

EPA estimates that facilities covered under this regulation will, on average, monitor their effluent for toxic organics once per quarter. However, some facilities may monitor as frequently as once per month. This analysis is performed for all plants to determine the impact of the costs associated with more frequent monitoring because EPA cannot determine precisely which facilities will be required to monitor on a monthly basis.

The capital investment cost required for monitoring monthly is the same as that for monitoring quarterly, $2,000. The annual operating and maintenance (O&M) costs for quarterly monitoring are $3,500 (as reported in Chapter 5); therefore, the annual O&M costs for monthly monitoring are $10,500 (quarterly costs times 3).

The methodology for analyzing impacts of monthly monitoring is the same as described in Chapter 2 of this report. Table A-1 summarizes the result

TABLE A-1. MONITORING COSTS SENSITIVITY ANALYSIS - ANNUAL COMPLIANCE COSTS AS A PERCENTAGE OF REVENUES[a]

PLANT ID CODE	TREATMENT OPTION 1	TREATMENT OPTION 2	TREATMENT OPTION 3	TREATMENT OPTION 5
A	.00	.27	.04	.29
B	.01	.27	.04	.34
C	.33	5.56	1.23	5.86
D	.04	1.54	.25	1.67
E	.02	.82	.14	.90
F	.00	.32	.04	.34
G	.01	.27	.04	.30
H	.02	.66	.11	.72
I	.01	.33	.05	.35
J	.01	.54	.07	.58
K	.02	.91	.13	.95
L	.22	3.95	.82	4.35
M	.04	1.73	.27	1.88
N	.09	.44	.32	.50
O	.26	1.57	.97	1.74
P	.04	1.21	.16	1.32
Q	.01	.37	.06	.40
R	.40	11.36	2.06	12.42
S	.00	.06	.01	.07
T	.22	3.38	.22	3.73
U	.02	.37	.08	.40

[a] The annual compliance costs for each option includes treatment costs, plus total annual monitoring costs which are estimated at $11,100. An annual operating and maintenance cost for monitoring of $10,500, plus an annual capital cost for monitoring of $600 per plant.

SOURCE: Compiled by JRB Associates.

of this analysis. For the sample impact plants, the annual costs for monthly monitoring is less than 0.4 percent of revenues for option 1, (selected option for BPT, PSES and PSNS) and less than 2.06 percent when the incremental costs of option 3 (selected option for BAT and NSPS) are included. While these costs have a greater impact than quarterly monitoring, they still remain below the threshold level for highly impacted plants.

Thus, while the impact of monthly monitoring is expected to be greater than for quarterly monitoring, the impacts are not expected to cause plant closures.

III. SOLVENT DISPOSAL SENSITIVITY ANALYSIS

EPA has determined that the incremental costs associated with improved solvent management techniques tend to be offset by resale of the solvents. Consequently, EPA did not cost out any small costs for the purposes of the impact analysis. Some facilities may have to haul away their solvents under the requirements of the Resource Conservation and Recovery Act (RCRA). Therefore, this analysis examined these "worst case" costs for RCRA hauling for all plants because EPA cannot determine which plants, if any, will fall under these requirements. These costs are not considered to be ordinary or average costs of compliance for facilities in this industry.

EPA estimated individual plant costs for each facility where possible. For remaining plants, and for model plants, the costs were extrapolated from plants with similar volumes of spent solvents. The costs used in the impact analysis appear in Table A-2.

The impact analysis was performed including the costs of monthly monitoring. This was done to determine the maximum possible impact on any one plant assuming that (1) the plant is required to monitor monthly; and (2) the plant chooses to dispose of its spent solvents under RCRA.

The analysis followed the methodology described in Chapter 2 of this part. Tables A-3 and A-4 summarize the results of the sensitivity analysis.

TABLE A-2. SEMICONDUCTOR INDUSTRY STATISTICS FOR SOLVENT DISPOSAL

PLANT ID CODE	TOTAL ANNUAL COMPLIANCE COST $ 1983	TOTAL ANNUAL COMPLIANCE COST $ 1979
A	1200.*	966.
B	14400.*	11592.
C	6800.*	5477.
D	1200.*	966.
E	1600.*	1288.
F	0.*	0
G	0.*	0
H	4000.	3220.
I	0.*	0
J	1600.*	1288.
K	4000.	3220.
L	6800.	5474.
M	4000.	3220.
N	4000.	3220.
O	6800.	5474.
P	4000.	3220.
Q	4000.	3220.
R	6800.	5474.
S	4000.	3220.
T	6800.	5474.
U	4000.	3220.

* Plant data provided by the Effluent Guidelines Division of EPA.

TABLE A-3. SOLVENT DISPOSAL SENSITIVITY ANALYSIS -
ANNUAL COMPLIANCE COSTS AS A PERCENTAGE OF REVENUES[a]

PLANT ID CODE	TREATMENT OPTION 1	TREATMENT OPTION 2	TREATMENT OPTION 3	TREATMENT OPTION 5
A	.00	.27	.04	.29
B	.01	.28	.05	.35
C	.49	5.72	1.39	6.03
D	.04	1.54	.25	1.67
E	.02	.83	.14	.90
F	.00	.32	.04	.34
G	.01	.27	.04	.30
H	.02	.67	.12	.73
I	.01	.33	.05	.35
J	.01	.54	.07	.58
K	.02	.91	.14	.96
L	.33	4.06	.93	4.46
M	.06	1.74	.28	1.89
N	.11	.47	.35	.52
O	.40	1.70	1.10	1.87
P	.06	1.22	.17	1.34
Q	.01	.37	.07	.40
R	.60	11.56	2.26	12.62
S	.00	.06	.01[b]	.07
T	.33	3.49	.33	3.84
U	.03	.37	.09	.41

[a] The annual compliance costs for each of the options include monitoring, solvent disposal, and treatment costs.

[b] Information on concentrated fluoride acid waste was not available for this plant.

SOURCE: Compiled by JRB Associates

TABLE A-4. SUMMARY OF SENSITIVITY ANALYSIS BY EMPLOYEE SIZE CLASSIFICATION[a]
(Percent)

SIZE CLASSIFICATION	AVERAGE ANNUAL COST TO REVENUES (%)			
	OPTION 1	OPTION 2	OPTION 3	OPTION 5
Small (1-99 employees)	.43	5.30	1.20	5.76
Medium-Small (100-499 employees)	.06	1.24	.26	1.35
Medium-Large (500-999 employees)	.03	.70	.12	.75
Large (1,000 >	.01	.31	.05	.37

[a] Profit impacts associated with monitoring, solvent disposal and treatment costs by employee size classifications.

SOURCE: Compiled by JRB Associates

The compliance cost to revenues ratio increases slightly over those for monthly monitoring only. For option 1, the compliance costs are less than 0.49 percent of revenues, and less than 2.26 percent when incremental option 3 costs are included. While these costs have a greater impact than quarterly monitoring alone, they still remain below the threshold level for highly impacted plants.

Thus, while the impact of monthly monitoring plus RCRA solvent disposal costs is greater than quarterly monitoring costs alone, the impacts are not expected to cause plant closures.

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